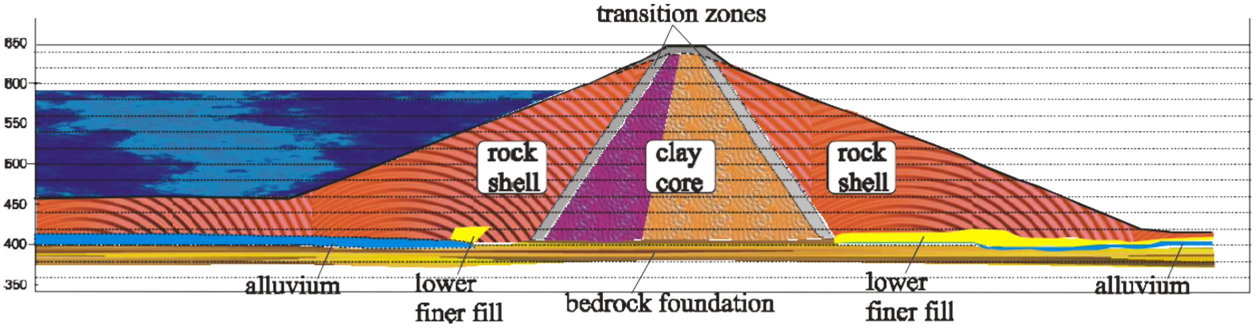
January 2014

2013 SURVEILLANCE REPORT
December 2012 through December 2013
LEROY ANDERSON DAM NO. 72-9
Santa Clara County



Santa Clara Valley
Water District

5750 Almaden Expressway, San Jose, CA 951 I 8-361 J | (08) 265-2600 | www.valleywater.org

Santa Clara Valley
Water District

January 6, 2014

Mr. David A Gutierrez , Chief
Division of Safety of Dams
Department of Water Resources
1416 Ninth Street
P.O. Box 942836
Sacramento, CA 94236-0001

Subject: Leroy Anderson Dam, No. 72-9, Santa Clara County
December 2012 through December 2013
2013 Surveillance Report

Dear Mr. Gutierrez:

Please find enclosed two copies of our 2013 surveillance report for Leroy Anderson Dam covering the period from December 2012 to December 2013.

Our review of the surveillance data and our periodic safety inspections indicate that Anderson Dam and appurtenant structures appear to show normal response to their environment , aging process, and external events. There were no major incidents or changes at the dam during 2013. All collected instrument data are well below established upper Action Levels. In addition , all collected instrument data are well above established lower Action Levels. Consequently , during the period of this report there were no surveillance instrumentation alarm conditions.

The Santa Clara Valley Water District will continue with the current monitoring program and safety inspections and will keep DSOD informed of any significant changes pertaining to the surveillance or performance of Anderson Dam. During the current reporting period, there were no new activities at the site that would impact monitoring of this facility.

Please contact me at (408) 630-2736, if you have any questions.

Sincerely,

Jim Fiedler

Jim Fiedler, P.E., D.WRE
Chief Operating Officer
Water Utility Enterprise

Attachments
cc/enc.: F . Maitski, T. Dougherty, H. Desai, M. Mooers, B. Baker, S. Wu, J. Nelson, library (4)
cc: H. Desai, L. Lopez
jn:mf
1231a-I.docx

2013 SURVEILLANCE REPORT
December 2012 through December 2013
LEROY ANDERSON DAM NO. 72-9
Santa Clara County

Date of photo 10/10/06
Photo shows temporary drill rig access roads and 2 drill rigs on dam crest for DIP

Prepared for:

State of California
Department of Water Resources
Division of Safety of Dams
P.O. Box 942836
Sacramento, CA 95236

Prepared by:
Santa Clara Valley Water District
5750 Almaden Expressway
San Jose, CA 95118

January 2014

2013 SURVEILLANCE REPORT
December 2012 through December 2013
LEROY ANDERSOJ'.'J DAM J'.'JO. 72-9
Santa Clara County

The analysis and inferpretalion of the instrumentation and other relevant data presented in this report has involved the application of certain graphical and slatislical inlerpretive techniques common to the geosciences and earth dam engineering professions. The conclusions presented in this report were developed upon evaluating lhe performance of all instruments and other pertinent data during the specified period, and represent the professional judgment of its author. This report was published on December 31, 2013.

Report prepared by:

PROFESSIONAL GEOLOGIST
JAMES LEWIS
NELSON
No. 1463
CERTIFIED
ENGINEERING
GEOLOGIST
STATE OF CALIFORNIA

James L. Nelson, C.E.G.
Senior Engineering Geologist
Dam Safety Program Unit

Quality Control/Quality Assurance

This report has been reviewed and approved for publication by the undersigned professional engineers. I attest and confirm that the report was prepared by the individual who signed the report under my immediate direction and supervision and that the conclusions and recommendations presented herein are reasonable and supported by District management.

Reviewed and approved by:

Hemang Desai, P.. E.
Engineering Uni Manager
Dam Safety Program Unit

Reviewed by:

Michael Mooers, P.E.
Associate Engineer
Dam Safety Program Unit

REGISTERED PROFESSIONAL ENGINEER
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1.0 INTRODUCTION

1.1 Scope and Purpose

The focus of this report is to provide a summary of our review of the annual monitoring data collected by the surveillance instrumentation at Leroy Anderson Dam, No. 72-9, from December 2012 through December 2013, and to make assessments of general data trends. If any significant geotechnical or operational events have occurred (i.e., earthquakes, sustained elevated reservoir levels, significant operational or maintenance changes, or dam instrumentation/monitoring changes), these are addressed as soon as possible after detection and summarized in this report.

This report provides historic long-term data plots (since the installation date of sensor) and short-term plots (~ 5 years) of instrument readings. The reader is referred to previous reports for earlier data plots and observations.

1.2 DSOD's Comments on Previous Report

Our annual surveillance reports address comments by DSOD on surveillance reporting from the last DSOD field inspection report, or other dam related issues. During the current reporting period DSOD performed an annual inspection of Anderson Dam on April 22, 2013. According to their latest inspection report dated May 8, 2013, DSOD (2013) stated that "*The available instrumentation data indicates the dam is performing satisfactorily. No additional instrumentation is deemed necessary at this time*."

1.3 Anderson Dam Seismic Retrofit Project (ADSRP) Design Consultant

The Anderson Dam Seismic Retrofit Project (ADSRP) is currently in the design phase. URS is the District's design consultant. Completion of design is expected by 2015 and construction is expected to be completed by 2018.

1.4 Changes to Surveillance Report

1.4.1 General

Based on input from DSOD we have made several changes to this report involving data presentation and analysis. Specific details of changes made to this report are summarized in this section. We intend to make appropriate additional changes in future reports to further optimize data review.

Despite the changes to the reporting format, the District will continue to internally review and evaluate all active instrumentation and data under all conditions on a monthly basis. The District will also continue our periodic inspections, and will keep DSOD informed of any significant changes pertaining to surveillance or performance of the dam. The following sections present our modified approach.

1.4.2 Proposed Implementation of "Reporting Requirement Monitoring Program" (RRMP)

During a teleconference on Thursday July 11, 2013, the District and DSOD discussed details of the Reporting Requirement Monitoring Program (RRMP) for District Dams that attempts to reduce the number of reported data and expedite review of relatively large amounts of surveillance data. The July 11 discussion focused primarily on monitoring at Stevens Creek Dam. Consequently, the District used the general discussion of requirements taken from Stevens Creek and applied them to all District Dams where applicable.

In this section we provide details for establishing an RRMP for Anderson Dam sensors. At some dams there are more than enough sensors (i.e. piezometers, discharge weirs, survey monuments, in-place inclinometers) to adequately characterize site conditions and dam performance. With DSOD concurrence, the program will aid review of overall dam performance by eliminating redundant or less critical sensors reported in the annual surveillance reports, unless we detect some noteworthy trends that warrant notification of DSOD. The Reporting Requirement program does not affect the District's internal review process. The District will continue to plot and review all surveillance data.

For Anderson Dam the only anticipated change is that plots of in-place inclinometers will not be provided in the annual surveillance reports and discussed in S*ection 6.2.1 No Longer Provide Plots of In-Place Inclinometer Data*.

1.4.3 Piezometer Monitoring Program

We will continue to monitor and report on all of the existing piezometers in the embankment and foundation in this and future annual surveillance reports.

1.4.4 Piezometer and Weir Cross Plots

As discussed, to streamline the surveillance report review process, and as requested by DSOD, we will no longer include piezometer and weir cross plots in our surveillance reports. However, the District will continue to internally produce and review cross plots as part of our regular monthly review of surveillance data.

1.4.5 "Short Term" and "Long Term" Time Series Plots

To comply with a DSOD request, the District will provide two types of time-series plots in annual surveillance reports. During a recent telecom on July 11, 2013, DSOD engineers Andy Mangney and Bill Vogler indicated DSOD prefers dual plots, which consist of a "short term" plot, that shows data trends over the last ~5-years, and a "long term" plot that shows historic data trends during the entire life of the sensor.

1.4.6 Action Levels

The District previously developed and plotted Action Levels in the 2012 report (Nelson, 2012) based on historic data for each monitoring instrument. Based on input from DSOD, we have reviewed and revised the definition and determination of 2012 Action Levels. Revised Action Levels values will be provided in this report and will be updated in future reports as needed.

1.4.7 Updated Action Levels

Updated Piezometric Action Levels - Based on input from DSOD and to aid in evaluating the ongoing performance of Anderson Dam, we will now use an appropriate “design” maximum phreatic line(s) in the maximum section through the dam (Figure 3) to define Action Levels representative of the upper/maximum/design condition. The objective for ongoing dam safety surveillance reviews is to compare the maximum excursion of the phreatic surfaces during any given year from piezometer data, to the design phreatic line.

For the first time in this report, we provide Action Level values for each sensor at the bottom (yellow shading) the respective table (Tables 2 through 7).

> The 1996 stability analysis of record for establishing the phreatic surface is herein considered to be the third Part 12D Safety Inspection and Report by R.L. Volpe & Associates (1997). The phreatic surface from sections developed in 1996 by R.L. Volpe & Associates (1997) for stability analysis is shown in Figures 2 and 3. The GEI evaluation of thresholds values and action levels (GEI, 2009) are based on the R.L. Volpe & Associates analysis. Also, for this report we added approximate equipotential lines developed by GEI (2009) to Figures 2 and 3.

Action Levels of Piezometers – We have elected to use single value Action Levels for the piezometers as summarized on the bottom of Tables 2 and 3 in yellow highlight (pages 11, 12, and 13). These are based on an estimated projection of the historic maximum at the 2011 reservoir elevation restriction of ~602.3 feet.

Updated Spillway Underdrain Weir Action Levels – We have elected to use a single value of ~172 gpm for the new Action Level for total underdrain discharge from weirs No. 1 and No. 2 at the left terminus of the spillway chute as summarized in Table 4 in yellow highlight (page 15). This is based on an estimated projection of the historic maximum at the reservoir elevation restriction ~602.3 feet.

Updated Survey Action Levels – The District did not update the ±0.05 feet Action Level values for the annual monitored survey monument movement data from Anderson Dam crests as shown on Table 5, page 17. This Action Level is the current value for all District Dams.

Updated In-Place Inclinometer Action Levels – The District did not update the +0.05 feet Action Level values for the in-place inclinometer movement data from Anderson Dam as shown on Table 7, page 20. This Action Level is the current value for all District Dams.

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2.0 SEISMIC, SEEPAGE or OTHER SIGNIFICANT EVENTS, and OTHER CHANGES

2.1 Noteworthy Seismicity

There were no earthquakes greater than M_L 5.0 during the reporting period December 2012 through December 2013 within a 50-mile radius of Anderson Dam. Significant earthquakes are defined as having approximate magnitudes greater than 5.0 (M_L).

Noteworthy earthquakes, defined as having approximate magnitudes less than M_L 5.0 but greater than about 4.0 occurring within 50 miles of the dam, occurred at one location in the San Francisco Bay Area, during the reporting period from December 2012 through December 2013 (Figure 19) with the following date, magnitude, distance and direction from Anderson Dam.

1. On July 28, 2013, M_L 3.9 earthquake, ~30 miles southeast

2.2 Noteworthy Seepage

There is no long-term historic seepage at Anderson Dam. Therefore, no new noteworthy seepage was observed during the reporting period.

2.3 Other Events

None to report.

2.4 Other Changes

This section summarizes changes and additions made to monitoring data collection and general surveillance reporting at Anderson Dam since the last report (Nelson, 2012). The following are noteworthy changes.

2.4.1 Tailwater and Headwater Alarms

In October 2011, the District implemented a Downstream Tailwater System and Upstream Headwater System to improve detection time for Time-Sensitive Emergency Action Plans (EAPs) downstream of Anderson Dam. An existing downstream gauge station 82, located ~1 mile downstream on Coyote Creek was upgraded to serve as a tailwater alarm system. A suitable headwater monitoring system has been established upstream of the dam. The District has developed suitable Action Levels and procedures for directly responding to alarms.

The Dam Safety Program Unit is working directly with District Hydrographers in the Hydrology, Hydraulics and Geomorphology Unit. The following describes the procedure for alarm notification. The District's ALERT system has a dual notification capability to the On-Call Hydrographer staff for redundancy. The system pages and starts an autodialer that contacts the On-Call Hydrographer, who then notifies Dam Safety Program Unit staff with a page, phone call and/or e-mail. The On-Call Hydrographer verifies that the alarm is real and contacts dam safety program staff with the results, and then resets the alarm.

2.4.2 Tabulated Action Level Values

The tabulated data for each sensor now include applicable Action Levels (Tables 2 through 7). For the first time, the District is providing tabulated data for vibrating wire piezometers (Table 3), which summarizes selected monthly piezometer data for each VWP. Prior surveillance reports provided plotted data of the VWPs only and not tabulated data. For convenience we selected readings from the middle of the respective month for the tabular data of ADAS VWPs, which is the approximate time monthly readings are taken for the non-ADAS piezometers (manually read pneumatic and open well piezometers, Table 2, page 11).

2.4.3 Implemented Earthquake Assessment Software ShakeCast

In mid-2012 the District implemented a new software program ShakeCast to help assess the impact of earthquakes on District dams including Anderson Dam. ShakeCast (short for ShakeMap Broadcast a software developed by the U.S.G.S.) is a free software package that provides post-earthquake situational awareness application to automatically retrieve earthquake shaking data from the U.S.G.S.'s ShakeMap server, compare intensity measures against the District's facilities, and generate potential damage assessment notifications, facility damage maps, and other Web-based products for the District's emergency managers and responders.

Consequently, in the event of an earthquake large enough to damage facilities the software will alert District dam safety personnel and provide a ranking of predicted damage to facilities that can be used to prioritize inspections. It also allows the District to use scenario earthquakes to test facility response plans.

3.0 RESERVOIR OPERATION

3.1 Reservoir Restriction

Based on findings from their technical memorandum 7 (TM-7), AMEC (2011b) recommended a revised operating restriction between 40 and 45 feet. In a letter dated April 12, 2011, the District proposed a restriction of 45 feet at elev. 602.3 feet (NAVD88). This restriction would be in place until the seismic retrofit of the dam is completed, which is currently anticipated to be the end of 2018; however, the District may request a modification to the restriction following completion of the retrofit for the downstream embankment. This restriction was approved by FERC and DSOD.

In recent years due to reservoir restrictions there has been an overall lowering of maximum reservoir excursions. The last time Anderson Reservoir spilled was in April 2006 (Nelson and Volpe, 2006).

3.2 Annual Reservoir Level

This section briefly describes reservoir fluctuations during the current recording period. Figure 5 is a plot of daily values of Anderson Reservoir elevations and daily rainfall data since January 2006. A discussion of reservoir elevations is pertinent to piezometric responses in the dam and foundation because the responses are potentially influenced by changes in reservoir levels.

Figure 5 shows daily reservoir fluctuation from January 2006 through December 2013 (gray shading indicates new data since the 2012 report). The preponderance of rainfall for any given calendar year typically occurs during January through April/May. Figure 5 shows detailed daily reservoir elevation changes and also shows daily local rainfall.

For the current reporting period, the reservoir level has been well below the 2011 restriction of elev. 602.3 ft. In recent years due to dry weather and reservoir restrictions there has been an overall lowering of maximum reservoir excursions. A minor peak in reservoir elevation occurred in January 2013 which was then followed by a steady decrease, attributable to relatively heavy rainfall in December 2012 and followed by a steady period of dry weather. From March 2013 to August 2013, however, the reservoir levels progressively increased during a dry period with a peak from July 31 through August 2, 2013 due to water imports from the Federal San Felipe project. The maximum reservoir level for 2013 was elev. 583.1 feet (6/31/13 through 8/2/13) and the minimum elev. of 570.6 feet was on December 22, 2012. These reservoir elevations are similar to the max/min for 2012.

4.0 MONITORING DATA and ANALYSIS

4.1 General

The Santa Clara Valley Water District (District) monitors data from the following instruments at Anderson Dam:

1) Thirty Six (36) Piezometers, consisting of:
    a. Three (3) downstream open well piezometers with,
        One (1) in the lower finer fill (LFF)
        Two (2) in foundation soils (Qa and Qc)
    b. Two (2) pneumatic piezometers in the foundation and core
    c. Fifteen (15) vibrating wire piezometers in the downstream core
    d. One (1) vibrating wire piezometers in the upstream core
    e. Six (6) vibrating wire piezometers in the transition zone (two upstream and four downstream)
    f. Seven (7) vibrating wire piezometers in the foundation bedrock
    g. Two (2) vibrating wire piezometers in the foundation soils and,
2) Two (2) spillway underdrain weirs located downstream of the spillway
3) Fifteen (15) crest survey monuments, (Monument Nos. 16 thru 30)
4) Three (3) spillway wing wall monuments (Monument Nos. 13, 14, & 15)
5) Six (6) in-place inclinometers through the maximum section, consisting of inclinometers (IPIs9-1 through IPIs9-6)
6) Seven (7) U.S. Geological Survey strong motion accelerometers on the crest and downstream of Anderson Dam
7) One (1) seismograph located in the crest block house
8) One (1) headwater alarm located upstream of Anderson Dam
9) One (1) tailwater alarm is located along Coyote Creek ~ 1 mile downstream of Anderson Dam.

All new data covered in this report is presented in tabular form (except inclinometer) and plotted to facilitate review.

Figure 1 show Anderson Dam as well as the locations of surveillance points in plan view. Figures 2 through 4 show transverse and longitudinal sections as A-A' through C-C' of Anderson Dam.

All elevation data presented in this report have been adjusted for the current datum used by the District Dam Safety Program, which is the North American Vertical Datum (NAVD) 1988, which is 2.80 feet higher than the old datum, National Geodetic Vertical Datum (NGVD) 1929, at this location.

Reported rainfall is measured at District Rain Gauge No. 41-2073, which is located a few hundred feet southeast of the left abutment of Leroy Anderson Dam.

4.2 Presentation of Data

All surveillance data are depicted graphically as time-series plots. As indicated in *Section 1.4.5 "Short Term" and "Long Term" Time Series Plots*, the District will provide two types of time-series plots in annual surveillance reports. The following are plots provided in this report:

- Figure 5 is a time-series plot of historic daily reservoir and rainfall data.
- Long-term and short-term surveillance data of all piezometers at Anderson Dam are depicted as time-series plots as shown in Figures 6 through 11. For each group of piezometers the long-term plot is at the top of each plot and the short-term piezometer surveillance for the same data are shown at the bottom. For the vibrating wire sensors at Anderson Dam (Figures 7 through 11) we decided to plot data since 2010 (~4 years) for the short-term plots of the piezometer data instead of ~ 5 years because the long-term plots only go back to 2007 (~7 years) when the sensors were installed. Long-term plots of the original pneumatic and open well piezometers go back to the dates these sensors were installed, which ranges from 1975 (PPA-1 and PPA-2) to 2009 (OW-2 and OW-3).
- The spillway underdrain weir surveillance data is depicted as a long-term time-series plot in Figure 12a and as a short-term series plot in Figure 12b.
- Long-term and short-term crest monument survey data from Anderson Dam are depicted in Figures 13 and 14, respectively. Figure 13 shows all vertical displacement data for both upstream and downstream crest monument, while Figure 14 shows all transverse displacement data for the same monuments.
- Long-term and short-term vertical spillway training wall monument survey data from Anderson Dam are depicted in Figure 15.
- In-place inclinometer data are depicted as “deflection versus depth” plots in Figure 16.

4.3 Treatment of Outlier Data

Surveillance data that lies outside established Action Levels are considered outlier data. The District Dam Safety program Unit (DSPU) defined a rigorous formal process to respond to outlier data to determine if they represent unsafe conditions. That process is formally outlined in our QEMS process procedures (SCVWD, 2012), and consists of the following basic steps:

- As soon as the outlier data is identified in our internal monthly data review and analysis, it is reviewed by the District DSPU geologist, and a preliminary inspection performed, if needed, to determine if it is a simple reporting error or instrument malfunction.
- If not, the District geologist reports the incident to the District DSPU engineer and the District conducts a field inspection.
- If there is still a concern following the inspection, DSPU staff report the incident to DSPU Unit Manager and District management, and contact DSOD if deemed necessary.
- Appropriate action is taken to resolve the concern
- Outlier data and District response/assessment are reported in the next annual DSOD surveillance report

Outlier data for each type of instrument monitored, if applicable, is discussed in the following sections.

4.5 Piezometer Data

4.5.1 General

All piezometer data from Anderson Dam are obtained from pneumatic, open well, or vibrating wire piezometers that have limited sensing zones in either the embankments or the dam foundations. The pneumatic and open well piezometers are read manually on a monthly basis. All the vibrating wire piezometers are monitored with an automated data acquisition system (ADAS).

The locations of VWPs are shown in plan and section views on Figures 1 through 4. For the period of this report, ADAS VWP data were collected approximately once daily. Manual non-ADAS piezometers OW-1, OW-2, OW-3, PPA-1, and PPA-2 are collected approximately once a month.

Numerous open well, pneumatic, and vibrating wire piezometers have been installed at Anderson from 1975 through 2009 for various studies of the Anderson Dam, ranging from monitoring requirements for static and seismic stability evaluations (SSE) (Wahler Assoc., 1978; AMEC, 2011a), general monitoring as required by FERC (Nelson, 2003), and as a part of a Dam Instrumentation Program (DIP) in 2007-08 (Fugro, 2007).

Figures 1 through 4 show Anderson Dam embankment piezometers in red, bedrock abutment and foundation piezometers in blue, transition zone piezometers in yellow, and one Lower Finer Fill piezometer in olive green (OW-2). It should be noted that most of the sensing zone of pneumatic piezometer PPA-2 is in the embankment with the lower portion in the foundation. Consequently, the symbol in the section views (Figures 3 and 4) show both red for the upper part and blue for the lower part.

To aid review of the piezometer data in Figures 6 through 11, we color coded plot lines based on the information each piezometers are measuring. Red lines depict piezometers in the downstream and upstream embankment, blue lines are for foundation bedrock piezometers, green lines are for foundation alluvium/colluvium piezometers, and olive is for the single Lower Final Fill piezometer (OW-2).

The following sections provide information on grouped piezometers in the order of 1) Original pneumatic piezometers, 2) open well piezometers, and, 3) vibrating wire piezometers.

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Table 1
Locations of Vibrating Wire Piezometers
Pneumatics and Open Well Piezometers
Leroy Anderson Dam

Embankment Piezos		
Downstream Core Zone 3	Tip Elev. (ft)	Surface Elev. (ft)
1) 72-9-02	480	647
2) 72-9-03	531	647
3) 72-9-04	580	647
4) 72-9-05	484	631
5) 72-9-10	430	647
6) 72-9-11	480	647
7) 72-9-12	530	647
8) 72-9-13	580	647
9) 72-9-20	550	647
10) 72-9-22	450	647
11) 72-9-23	500	647
12) 72-9-24	550	647
13) 72-9-26	550	647
14) 72-9-29	444	614
15) 72-9-30	490	614
16) PPA-1	540	647
17) PPA-2*	435	647
Upstream Core Zone 2	Tip Elev. (ft)	Surface Elev. (ft)
18) 72-9-14	470.0	630.0

Transition Zone		
Downstream	Tip Elev. (ft)	Surface Elev. (ft)
19) 72-9-07	557	619
20) 72-9-08	518	602
21) 72-9-16	539	614
22) 72-9-17	421	583
Upstream	Tip Elev. (ft)	Surface Elev. (ft)
23) 72-9-06	587.0	631
24) 72-9-15	587.0	630.0

Foundation Fill Lower Finer Fill		
Foundation	Tip Elev. (ft)	Surface Elev. (ft)
25) OW-2	406	508

Bedrock Foundation		
Foundation	Tip Elev. (ft)	Surface Elev. (ft)
26) 72-9-01	453	647
27) 72-9-9B	382	647
28) 72-9-18	580	647
29) 72-9-19	516	647
30) 72-9-21	400	647
31) 72-9-25	500	647
32) 72-9-27	585	647

Alluvial/Colluvial Foundation		
Foundation	Tip Elev. (ft)	Surface Elev. (ft)
33) 72-9-28	405	486.0
34) 2-9-31	600	647
35) OW-1	399	417
36) OW-3	408	551

Note:
1) PPA-2 sensing zone is mostly in embankment w/lower portion in foundation
2) W:\Geology\DAMS\Annual Dam Safety Reports\FERC\Annual Reports\2013\piez\Andtab1-13.xls

Pertinent data for the vibrating wire piezometers of Anderson Dam are summarized in Table 1. As summarized in Table 1, locations of the piezometers include 15 VWPs in the downstream core (Zone 3) of the embankment, 1 VWP in the upstream core (Zone 2) (with core piezometers shown as red symbols in Figures 2, 3, and 4), 4 VWPs in the downstream transition zone (yellow symbols), 2 VWPs in the upstream transition zone (yellow symbols), 2 VWPs in alluvium/colluvium (green symbols), and 7 VWPs in foundation Franciscan Complex bedrock (blue symbols). Original pneumatic piezometer PPA-2 is a composite piezometer with most of the upper sensing zone in the embankment and the lower portion in the foundation.

4.5.2 Original Pneumatic and Open Well Piezometers

Pertinent data for all the piezometers of AndersonDam are summarized on Table 1, including the location of each piezometer tip in specific zones of the embankment or the foundation.

In November 1975, W.A. Wahler & Associates installed two pneumatic piezometers PPA-1 and PPA-2 in boring AD-1 at Anderson Dam to monitor the phreatic surface through the upper and lower embankment of the central core near the maximum section of the embankment. The two pneumatic piezometers PPA-1 and PPA-2, show slight fluctuations and response to changes in reservoir levels but are still operational after 38 years of service.

As required by FERC, the District (Nelson, 2003) installed an open well standpipe piezometer (OW-1) in August 2003 about 50 feet downstream of the downstream toe of the dam, and about 100 feet north-northwest of the Coyote Creek Turnout Facility. This piezometer was installed to monitor the phreatic surface in native ground immediately downstream of the embankment toe.

In 2009 AMEC/Geomatrix (AMEC, 2011a) installed two open well standpipe piezometers (OW-2 and OW-3) through the downstream shell into foundation materials in two of the borings (DH9-37SPTb and DH9-49, respectively) to provide phreatic surface information needed to assess the Seismic Stability Evaluation (SSE1A) of Anderson Dam.

As summarized in Table 1, piezometer OW-2 targets the phreatic surface of a lower fine-grained unit of rockfill embankment encountered during the SSE1A investigation and identified as the "Lower Finer Fill" (LFF) at depths between 89 feet and 105 feet (~elev. 403 feet and 419 feet). Well OW-3 targets the phreatic surface of various foundation soils including construction haul road fill and alluvium at depths between 132 feet and 141 feet (~elev. 410 feet and 418 feet). It is noteworthy that because OW-2 is located at a low elevation beneath the embankment this open well is functioning as a foundation piezometer and thus is grouped with other foundation piezometers.

4.5.3 Pneumatic and Open Well Piezometer Data

Recent pneumatic and newer open well piezometer data collected since our last report (Nelson, 2012) from December 2012 through December 2013 are summarized in Table 2. Also shown at the bottom of Table 2 are the Action Levels (yellow shading) for each piezometer. Methods for determining these levels are summarized in Appendix A of the 2012 surveillance report (Nelson, 2012).

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TABLE 2
Recent Piezometric Data - Non-ADAS Read Piezos
Leroy Anderson Dam)

Date	Reservoir Level (ft)	PPA-1	PPA-2	OW-1	OW-2	OW-3	Monthly* Rainfall (in)
		Piezometric Surface Elevation (ft)					
12/19/12	570.8	565.9	486.3	406.3	406.6	411.8	5.9
1/15/13	577.6	567.2	487.5	406.3	406.5	411.8	1.3
2/19/13	572.9	567.0	487.3	406.4	406.0	411.7	0.2
3/20/13	572.6	564.9	481.8	406.4	405.9	411.6	0.8
4/19/13	575.2	560.3	485.2	405.2	406.0	411.5	0.3
5/15/13	579.5	564.9	487.6	405.8	406.4	411.7	0.0
6/18/13	580.1	562.4	484.0	405.8	406.3	411.5	0.0
7/16/13	580.4	562.6	483.1	405.8	406.4	411.6	0.0
8/19/13	582.6	561.3	483.2	405.8	407.5	411.6	0.0
9/15/13	581.8	NR	NR	NR	NR	NR	0.0
10/15/13	578.6	NR	NR	NR	NR	NR	0.0
11/21/13	575.5	560.3	483.0	406.3	407.4	411.6	0.6
12/17/13	572.5	563.7	483.1	406.6	406.7	411.7	0.6
Action Levels *		583.5	517.1	408.0	408.6	413.9	

Notes:
1) Piezometer data is Piezometric Surface Elevation (PSE in feet)
2) PSE = pressure head (ft) + elevation head (ft)
3) basis of elevations is NAVD 1988 - values in this table are 2.8 feet higher
than NGVD 1929
4) Installation dates: OW-1 on 8/5/03, OW-2 on April 30, 2009, and OW-3 on May 1, 2009
5) * yellow shading = action levels tied to 2011 reservoir restriction: see Nelson 2012
6) NR = no readings due to readout box repair
7) file: W:\Geology\DAMS\Data\Pz\Anderson.xls

Figure 6 shows combined plots of long-term piezometric surface elevations (PSE) of the pneumatic and open wells at the top (Figure 6a) and short-term PSE values (Figure 6b) versus time on bottom of the same page. The PSE is defined as the sum of the piezometer tip elevation (feet) and the hydraulic pressure head (feet). Specifically, Figure 6a is an historic time series plot from 1975 through December 2013 (~38 years) while Figure 6b shows the same data from January 2009 through December 2013 (~last 5 years).

Table 2 and the gray area of Figure 6 show data since our 2012 report (Nelson, 2012).

4.5.4 Outlier Pneumatic and Open Well Piezometric Data

For the period of this report, maximum piezometer PSE values for all piezomeers at Anderson Dam are well below the new Action Levels established for the embankment and foundation piezometers. There are no outliers.

4.5.5 Vibrating Wire Piezometers

From September 2006 through January 2007, the District installed 31 vibrating wire piezometers (VWP) during the 2006/2007 Dam Instrumentation Project (DIP) (Fugro West, 2007). The District manually collected data from 31 VWPs from their installation in late December 2006 until implementation of ADAS in early December 2008. Most data since December 2008 has been automatically collected by ADAS. For the period of this report, ADAS VWP data were collected once daily.

The locations of the VWPs are shown in plan view in Figure 1 and in section views in Figures 2, 3, and 4.

4.5.6 Vibrating Wire Piezometer (VWP) Data

For the first time, the District is providing Table 3 to summarize selected monthly piezometer data for each VWP. For convenience we selected readings from the middle of the respective month for the tabular data of ADAS VWPs, which is the approximate time monthly readings are taken for the non-ADAS piezometers (Table 2, page 11).

The yellow highlighted values at the bottom of Table 3 are the Action Levels for each piezometer. Methods for determining these levels are summarized in Appendix A of the 2012 surveillance report (Nelson, 2012).

Table 3
Recent Piezometer Data - Vibrating Wire Piezometers
Leroy Anderson Dam

Date	Reservoir Level (ft)	ADAS Read Piezometers								Monthly Rainfall (in)
		1	2	3	4	5	6	7	8	
12/16/2012	570.95	453.35	509.88	555.62	578.63	499.18	587.35	556.93	517.24	5.9
1/20/2013	577.30	453.52	509.72	555.20	578.56	NR	NR	557.07	517.36	1.3
2/16/2013	573.30	453.57	509.57	554.89	578.49	499.20	587.46	557.13	517.41	0.2
3/19/2013	572.60	453.40	509.64	554.63	578.44	499.06	587.32	556.99	517.24	0.8
4/15/2013	575.10	453.20	509.48	554.38	578.34	498.83	587.06	556.75	516.98	0.3
5/15/2013	579.60	453.37	509.31	554.14	578.28	498.84	587.19	556.86	NR	0.0
6/15/2013	580.20	453.31	509.13	553.94	578.29	498.88	587.11	556.80	517.09	0.0
7/15/2013	580.40	453.39	508.98	553.88	578.23	498.55	587.18	556.87	517.12	0.0
8/15/2013	582.70	453.39	508.84	553.88	578.23	498.70	587.14	556.86	516.99	0.0
9/15/2013	581.80	452.82	508.70	553.91	578.10	498.80	586.94	556.70	516.80	0.0
10/15/2013	578.60	452.85	508.59	553.99	578.28	498.66	587.15	556.93	NR	0.0
11/13/2013	576.00	452.98	508.50	554.02	578.23	498.65	NR	557.17	517.04	0.6
12/8/2013	574.00	452.89	508.40	553.97	578.21	NR	NR	557.01	517.08	0.6
Action Levels *		454.98	527.12	569.72	586.13	503.84	605.28	558.92	520.53	

Table 3 (cont.)
Recent Piezometer Data - Vibrating Wire Piezometers
Leroy Anderson Dam

Date	Reservoir Level (ft)	ADAS Read Piezometers								Monthly Rainfall (in)
		9B	10	11	12	13	14	15	16	
12/16/2012	570.95	481.22	519.67	527.73	563.35	585.06	542.13	587.38	539.85	5.9
1/20/2013	577.30	480.98	520.58	527.49	563.14	585.15	541.76	587.35	540.51	1.3
2/16/2013	573.30	480.76	519.78	527.24	562.92	585.14	541.53	587.16	540.26	0.2
3/19/2013	572.60	480.53	519.56	526.99	562.55	584.96	541.27	586.84	539.93	0.8
4/15/2013	575.10	480.33	519.58	526.79	562.31	584.83	541.01	586.62	539.67	0.3
5/15/2013	579.60	480.22	519.88	526.72	562.32	584.94	540.86	586.67	539.70	0.0
6/15/2013	580.20	480.10	519.49	526.57	562.47	585.33	540.84	586.57	539.58	0.0
7/15/2013	580.40	480.02	519.47	526.50	562.61	585.39	540.93	586.52	539.49	0.0
8/15/2013	582.70	480.04	519.71	526.53	562.91	585.86	541.07	586.51	539.44	0.0
9/15/2013	581.80	480.04	519.49	526.53	563.16	586.06	541.24	586.28	NR	0.0
10/15/2013	578.60	480.06	519.37	526.52	563.25	585.83	541.35	586.52	NR	0.0
11/13/2013	576.00	480.02	519.32	526.48	563.12	585.33	541.33	586.67	NR	0.6
12/8/2013	574.00	479.96	519.21	526.41	562.86	584.95	541.20	586.61	539.47	0.6
Action Levels *		501.06	535.62	549.37	582.70	605.84	558.43	605.28	541.49	

Table 3 (cont.)
Recent Piezometer Data - Vibrating Wire Piezometers
Leroy Anderson Dam

		ADAS Read Piezometers								
Date	Reservoir Level (ft)	17	18	19	20	21	22	23	24	Monthly Rainfall (in)
12/16/2012	570.95	419.98	579.75	515.92	568.36	450.85	519.20	546.60	563.58	5.9
1/20/2013	577.30	420.12	579.89	516.05	568.58	451.96	518.91	546.29	563.27	1.3
2/16/2013	573.30	420.15	579.96	516.11	568.85	451.68	518.72	546.08	563.03	0.2
3/19/2013	572.60	420.05	579.82	515.95	568.14	451.42	518.49	545.60	562.73	0.8
4/15/2013	575.10	419.82	579.61	515.74	567.79	451.24	518.30	545.26	562.42	0.3
5/15/2013	579.60	419.94	579.72	515.84	568.26	451.16	518.15	545.10	562.23	0.0
6/15/2013	580.20	419.84	579.68	515.77	569.29	451.01	518.08	545.20	562.11	0.0
7/15/2013	580.40	419.96	579.77	NR	NR	450.90	518.04	545.21	561.98	0.0
8/15/2013	582.70	419.96	NR	NR	NR	450.92	518.06	545.43	561.92	0.0
9/15/2013	581.80	419.82	579.60	515.65	570.96	450.83	518.09	545.56	561.81	0.0
10/15/2013	578.60	420.03	579.82	515.87	570.83	450.79	518.12	545.64	561.74	0.0
11/13/2013	576.00	420.27	580.06	516.10	570.17	450.79	518.11	545.56	561.78	0.6
12/8/2013	574.00	420.12	579.90	515.93	569.41	450.72	518.04	545.34	561.71	0.6
Action Levels *		421.75	582.44	518.92	593.45	454.20	534.84	566.46	580.15	

Table 3 (cont.)
Recent Piezometer Data - Vibrating Wire Piezometers
Leroy Anderson Dam

		ADAS Read Piezometers							
Date	Reservoir Level (ft)	25	26	27	28	29	30	31	Monthly Rainfall (in)
12/16/2012	570.95	549.46	573.96	584.74	409.99	476.78	491.96	601.72	5.9
1/20/2013	577.30	550.35	573.49	584.87	410.87	476.74	491.82	601.67	1.3
2/16/2013	573.30	550.21	573.12	584.93	410.63	476.68	491.84	601.69	0.2
3/19/2013	572.60	549.47	572.77	584.78	410.19	476.66	491.82	601.69	0.8
4/15/2013	575.10	549.39	572.50	584.55	409.86	476.62	491.63	601.59	0.3
5/15/2013	579.60	550.18	572.21	584.66	409.84	476.57	491.55	601.57	0.0
6/15/2013	580.20	550.91	571.93	584.61	409.68	476.52	491.63	601.49	0.0
7/15/2013	580.40	551.08	571.78	584.68	409.69	476.43	491.53	601.34	0.0
8/15/2013	582.70	551.90	571.73	584.68	409.62	476.41	491.54	NR	0.0
9/15/2013	581.80	552.09	571.74	584.52	409.44	NR	NR	**787.35**	0.0
10/15/2013	578.60	551.80	571.85	584.76	409.98	NR	NR	**798.98**	0.0
11/13/2013	576.00	551.16	571.96	585.01	410.16	NR	NR	601.17	0.6
12/8/2013	574.00	550.49	571.98	584.85	409.97	476.16	491.85	601.12	0.6
Action Levels *		568.28	592.58	600.24	413.68	477.14	500.85	605.61	

Notes:
1) Basis of elevations is NAVD 1988 - elevations are 2.80 feet higher than NGVD 1929
2) NR = piezometer readings not recorded
3) * yellow shading = upper limit action levels tied to 2011 reservoir restriction: see Nelson 2012
4) bold red numbers = outlier data: see text
5) file: W:\Geology\DAMS\Data\Pz\Anderson\monthly.xls

The recent data obtained since our last report (Nelson, 2012) from December 2012 through December 2013 is shown as a shaded region in Figures 6 through 11 (both long-term and short-term data). Figures 7 through 9 shows time series data collected at sensors along cross sections A-A’, B-B’, and C-C’ through the dam as piezometric surface elevation (PSE) vs. time for each piezometer. The PSE is defined as the sum of the piezometer tip elevation (feet) and the hydraulic pressure head (feet). Figure 10 shows time series data collected at sensors in the foundation, and Figure 11 shows data collected in the transition zones. Reservoir elevation data is presented for reference.

The data in Figures 7 through 11 and on Table 3 indicate that fluctuations in embankment and foundation piezometric levels generally respond to fluctuations in reservoir level.

Due to power issues with various vibrating wire piezometers (VWP-5, 6, 8, 16, 18, 19, 20, 29, 30, and 31, see Table 3) there were minor data gaps ranging from ~1 to 3 months during 2013. The District is currently obtaining fairly continuous data readings from all the non-ADAS and ADAS instruments. Consequently, other than minor power issues (low batteries), there are no significant piezometer data gaps.

Except for VWP-31 (which beginning in September 2013 exhibited erratic behavior as discussed in the next section), the VWP piezometer data appear to be providing reliable and consistent data during the entire surveillance period.

4.5.7 Outlier VWP Piezometric Data

Except for VWP-31, the recent results of all piezometers monitored fall within the typical ranges of historical levels and the new Action Levels, where established. No abnormal readings or trends are evident.

In early September 2013 piezometer VWP-31, located in bedrock in the left abutment, became highly erratic as evident by large data fluctuations with values significantly greater than normal historic values. Normal readings from VWP-31 have been consistently in the elev. range of ~601 feet. The first erratic data point from VWP-31 had a value of 1019 feet on September 13, 2013, with subsequent values continuing into early November 2013 that ranged from 791 feet to 805 feet. The District decided from the first erratic point that these highly elevated values (hundreds of feet above normal historic readings) were most likely due to a faulty sensor and not related to dam safety concerns. Also, VWP-31 values have periodically returned to normal values of elev. ~601 to 602 feet in early, mid-, and late November. After providing two normal data points of elev. 601 feet in succession on November 24 and 25, VWP-31 again provided erratic behavior with values ranging from 784 feet to 1020 feet during the first week in December 2013.

These erratic values from VWP-31 are considered to be due to faulty hardware/electronic problems with the sensor and not related to adverse embankment/foundations conditions because the elevations were ~200 feet to 400 feet above normal readings. The District will perform field testing of the electronic equipment associated with VWP-31 to attempt to determine the reasons for the erratic behavior. The District will continue to monitor the behavior of VWP-31 and will keep DSOD apprised.

4.6 Spillway Underdrain System

4.6.1 General

There is no weir seepage monitoring of the embankment itself due to absence of historic observed seepage. An underdrain system, however, was installed in the spillway foundation to discharge probable reservoir water and groundwater that flows beneath the spillway. The concrete lined spillway is constructed on rock and dense terrace deposits on an elevated river terrace in the right abutment in an area that served as a borrow source for the rockfill shell. The underdrain system is constructed of 6, 8, and 12-inch diameter perforated pipe. Seepage collected by the center drainage system is measured by Weir No. 1. The remainder of the underdrain system collects seepage along the left side of the spillway from the downstream toe of the spillway crest to the spillway bucket. This seepage is measured by Weir No. 2.

Historically, two different methods for measuring Anderson Dam spillway underdrain discharge consisted of a former flow meter during the 1990s, which was changed to the current weir system in 2000. The initial discharge monitoring program spanned the period from 1993 to 1999 and consisted of measurements made using a flow meter that was attached to the "center" drainage system. This system of piping for the meter only collected seepage in the central portion of the spillway. The flow meter was removed during periods when the reservoir spilled to avoid damage or lose of the meter. During this period the "left" drainage system could not be measured and was discharged through boulders that were providing slope protection D/S of the spillway bucket. Only with newer weir system could the "left" drainage be effectively measured.

The current weir system constructed in 1999 allowed all discharge to be measured for the first time, instead of only measuring a portion of the flow as occurred with the original center drainage system mentioned above. Weir No. 1 measures the seepage from the "center" drainage system (essentially replicating the data from the former flow meter), but is not affected by the restriction and backpressure created by the use of a meter, as was the old system that it replaced. Weir No. 2 measures the seepage collected along the left (southern) side of the spillway.

Data from the weirs were not collected from April 2012 through March 2013 due to unsafe access conditions. Fortunately, this interval with no data from the underdrain weirs coincided with historically low reservoir levels and the data would likely have consisted of very low values or zero. The District constructed a permanent safe access ladder in November 2012 so that data could once again be safely collected by March 2013.

4.6.2 Spillway Underdrain Flow Data

Figure 12a shows long term historic weir data since 1993 with flow gauge reading from 1993 to 1999 and weir readings from 2000 to 2013. Figure 12b shows short term weir data collected from 2009 through 2013 (~5 years).

TABLE 4
Recent Weir Discharge Data – Spillway Underdrains
Leroy Anderson Dam

Date	Reservoir	Underdrain flow (gpm)		Total flow
	Level (ft)	Weir No. 1	Weir No. 2	(gpm)
12/19/2012	570.8	NR	NR	NR
1/15/2013	577.6	NR	NR	NR
2/19/2013	572.9	NR	NR	NR
3/20/2013	572.6	3.1	0.9	4.0
4/19/2013	575.2	1.8	6.3	8.1
5/15/2013	579.5	3.1	0.4	3.6
6/18/2013	580.1	3.1	0.9	4.0
7/16/2013	580.4	3.6	1.8	5.4
8/19/2013	582.6	3.6	2.3	5.8
9/15/2013	581.8	NR	NR	NR
10/15/2013	578.6	NR	NR	NR
11/21/2013	575.5	0.4	3.6	4.0
12/17/2013	572.5	0.4	1.8	2.2
Action Levels *		122.8	77.1	172.5

Notes: 1) Weir No. 1 collects flow from the central portion of spillway
2) Weir No. 2 collects flow from the left side of the spillway
3) NR = not read due to unsafe access and readout box in for repair
4) * yellow shading = action levels tied to 2011 reservoir restriction: see Nelson 2012
5) W:\Geology\DAMS\Data\Pz\Anderson.xls

The yellow highlighted values at the bottom of Table 4 are the Action Levels for each weir. Methods for determining these levels are summarized in Appendix A of the 2012 surveillance report (Nelson, 2012).

After a ladder was installed to address safety concerns in November 2012 the District began collecting weir data starting in March 2013. No weir data were collected in September and October 2013 because the field technician was not available due to repair of a readout box for the pneumatic piezometers. During this period the field technician did not read open well piezometers and the weirs because the pneumatic piezometers could not be read.

During 2013, the combined flow from the weirs ranged from a low of ~3.6 gallons per minute (gpm) (May 2013) to a high of ~8.1 gpm (April 2013). The overall flow is relatively small during the period of this surveillance report due to relatively low reservoir levels as discussed in *Section 3.2 Annual Reservoir Level*.

4.6.3 Outlier Underdrain Data

Since the time of our last report, the data indicates that weir discharge rates were within normal ranges from December 2012 through December 2013. The data in Figure 12 indicate that weir discharge rates fall within the typical ranges of historical levels and significantly below the established Action Levels shown highlighted in yellow on Table 4. There are no outliers.

4.7 Survey Monuments

4.7.1 General

Fifteen original dam crest monuments were installed immediately after dam construction in 1951. The original monuments were spaced at intervals of 100-feet on center from the left abutment to the right abutment. The original monuments were replaced with 16 crest monuments after dam modifications in 1988.

Modifications to Anderson Dam in 1988 included raising the dam crest 4 to 7 feet and widening the spillway to accommodate new Potential Maximum Flood (PMF) discharge requirements. Consequently, the existing surface monuments consist of a newer monitoring instruments installed after the 1988 modifications. These consist of crest monuments Nos. 16 through 31 and training wall monuments Nos. 13 through No. 15 as shown on Figure 1 and Figure 4 (transverse section view). The training wall monuments No. 13, No. 14, and No. 15, were a new feature, which allowed the two walls adjacent to the spillway weir to be monitored for movements. Roughly half the crest monuments are located along the downstream edge of the crest (Nos. 17, 19, 21, 24, 26, and 28) and half along the upstream edge of the crest (Nos. 18, 20, 22, 23, 25, 27, and 29). Monuments No. 16 and No. 31 are located at the left and right abutments, respectively.

As mentioned above, the crest monuments generally alternate between the downstream edge and upstream edge of the crest. Data plots have been grouped as either “upstream (U/S) edge” or “downstream (D/S) edge”. The location of the surface monuments are shown in Figure 1 (plan view) and Figure 4 (longitudinal section view).

For this report, the District presents monument survey data as plots of vertical displacement and lateral displacements. For the crest monuments the District converted the monument coordinates determined by surveys, to perpendicular offsets from a line between points on both ends of the dam.

4.7.2 Crest Monument Survey Data

During the period of this report, dam crest monuments No.16 through No. 30 were monitored and their locations are shown on Figure 1. The vertical and transverse data for Anderson Dam is presented in Figures 13 and 14, and summarized on Table 5.

Table 5 summarizes Anderson Dam crest vertical displacement and transverse displacement data for the survey monuments. We also included calculated movements since the 2012 report (Nelson 2012) at the bottom of each data set (i.e. from October 2012 to the October 2013 survey).

Also shown in yellow highlight are the Action Levels of ±0.05 feet. Methods for determining these levels are summarized in Appendix A of the 2012 surveillance report (Nelson, 2012).

TABLE 5
Vertical and Local Transverse Data - Crest and Abutment Monuments
Leroy Anderson Dam

Date	Cumulative Monument Vertical Displacement (feet) (since 1988) 16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
10/12/2012	0.02	-0.03	-0.05	-0.25	-0.19	-0.34	-0.29	-0.22	-0.35	-0.17	-0.12	-0.04	0.02	0.04	0.05
10/22/2013	0.01	-0.03	-0.05	-0.25	-0.19	-0.34	-0.30	-0.23	-0.36	-0.18	-0.13	-0.05	0.01	0.03	0.03
Action Levels	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05
change in disp. 10/12 to 10/13	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02
		Average change since last survey =					-0.01 or 0.0"								

Date	Cumulative Dam Crest Monument Local Transverse Displacement (feet) (since 1988) 16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
10/12/2012	0.00	-0.06	0.01	-0.14	-0.05	-0.19	-0.04	-0.13	-0.19	0.01	-0.04	0.08	-0.01	-0.03	0.00
10/22/2013	0.00	-0.06	0.00	-0.13	-0.03	-0.19	-0.02	-0.12	-0.17	0.03	-0.02	0.10	0.02	-0.05	0.00
Action Levels*	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05	+0.05
change in disp. 10/12 to 10/13	0.00	0.00	-0.01	0.01	0.02	0.00	0.02	0.01	0.02	0.02	0.02	0.02	0.03	-0.02	0.00
		Average change since last survey =					0.01	or 0.0"							

Notes:
1) Negative transverse displacement signifies downstream movement
2) Positive transverse displacement signifies upstream movement
3) Displacement is net displacement since 1988
4) NR = monument not surveyed (Mon. 31 destroyed during new boat ramp construction; Mon. 30 new control pt)
5) file:W:\Geology\DAMS\Annual Dam Safety Reports\Data\Survey\ANDsurvey.xls
6) Local Transverse data shown back calculated to 1988 - see tex
7) Mons #16 and 30 are control points and do not show local transverse displacement
8) * yellow shade = action levels: see Nelson 2012

As shown in Figures 13 and 14, the time-series (long term and short term) lines are color coded to generally depict the relative thickness of the embankment (depth from crest to foundation) directly beneath each monument on the vertical and transverse plots, where thicker dam sections are shown by hot colors and thinner sections are shown by cool colors. Red lines depict embankment thicknesses between ~150 feet and ~255 feet, blue is for embankment thicknesses between ~100 feet and 150 feet, and green is for embankment thicknesses between 0 feet and 100 feet. This gives a quick visual on whether monument movements are occurring on the more critical thicker sections relative to the less critical thinner sections of the dam.

The lines tend to group relative to color on Figures 13 and 14, with green lines (thinner section) generally plotting along the top, blue in the middle and red lines (thicker section) at the bottom of each plot. These trends indicate greater movements with time for thicker sections relative to thinner sections of the dam, which is typical for a large embankment dam with a significant differential in thicknesses. This appears to be generally true for both vertical and transverse displacements.

The crest monument surveys appear to be providing reliable and consistent data during the entire surveillance period.

4.7.3 Outlier Crest Monument Survey Data

Based on the recent data, during 2013 crest monument displacement values are well below the upper Action Levels. Due to the nature of displacement data, there are no lower Action Levels. There are no outliers.

4.7.4 Spillway Training Wall Monuments

Three survey monuments are located at the top of the spillway training walls, two on a wall on the left side of the spillway ogee (Mons. Nos. 14 and 15), and one on a wall on the right side of the ogee (Mon. No. 13), as shown in Figure 1. Due to difficult access Monument No. 13, on the right spillway wall, has not been monitored since October 2001. Previous spillway training wall horizontal and vertical survey results may be less reliable due to access issues. Because of the difficulty of accessing the monuments positioned at the bottom of a chain link fence, some errors may be introduced in the survey data from the spillway training walls (see Nelson and Volpe, 2004 for more information). Even with these limitations, this surveillance report provides historic data plots showing vertical displacement of Monuments 14 and 15 in Figure 15.

4.7.5 Survey Data – Training Wall

During the period of this report, training wall Monuments No.14 and No. 15 are monitored and their locations are shown on Figure 1. The vertical data for the training walls presented in Figure 15, and summarized on Table 6. Net vertical displacements since the last surveillance report (i.e. from October 2012 to October 2013) is shown at the bottom of each data set on Table 6.

Also shown in yellow highlight on Table 6 are the Action Levels of ±0.05 feet. Methods for determining these levels are summarized in Appendix A of the 2012 surveillance report (Nelson, 2012).

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TABLE 6
Vertical Displacement Data
Spillway Training Wall Monuments
Leroy Anderson Dam

Date	Monument Vertical Displacement (feet)		
	13	14	15
10/12/2012	NR	0.04	0.06
10/22/2013	NR	0.04	0.04
Action Levels*	±0.05	±0.05	±0.05
change in disp. 10/12 to 10/13	NR	0.00	-0.02

vg. change since 10/11 -0.01 or 0.12"

Notes:
1) Negative vertical displacement represents settlement
2) Positive vertical displacement represents heave
3) * yellow shade = action levels: see Nelson 2012
4) file:W:\Geology\DAMS\data\survey\AndTranWallVert.xls

Survey results of training wall monuments indicate minimal horizontal and vertical displacements (less than 0.02 ft in the vertical plane) have occurred during this reporting period. These small displacements indicate that only minimal, normal displacements of the training walls have occurred during this reporting period with no obvious trends.

4.7.6 Outlier Training Wall Monument Survey Data

The spillway training wall surveys appear to be providing reliable and consistent data during the entire surveillance period.

Based on the recent data, during 2013 spillway training wall monument displacement values are well below the upper Action Levels. Due to the nature of displacement data, there are no lower Action Levels. There are no outliers.

4.8 In-Place Inclinometer Sensors (IPIs)

During the 2006-2007 DIP, the District installed an inclinometer casing in a crest borehole near the maximum section of the dam that fully penetrated the embankment with the bottom of the casing embedded approximately 10 feet into competent stable bedrock (Fugro West, 2007). Multiple automated bi-axial sensors (in place inclinometers or IPIs) manufactured by Applied Geomechanics (model 906 Little Dipper IPIs) were placed vertically in the single crest inclinometer boring using fiberglass rods that connect and suspend the individual IPIs successively in a vertical column.

The purpose of these instruments is to monitor gross deformations of the embankment as a result of events such as significant earthquakes or rapid draw-down of Anderson reservoir. To supplement the bi-axial sensor data, we also plan to perform conventional manual inclinometer surveys soon after significant seismic events, or more frequently as needed.

Six Little Dipper bi-axial sensors known as in-place inclinometer (IPIs) are located in inclinometer boring IPI9-1 (boring 72-9-ASI-1) shown on Table 7 and in Figure 1 (plan view) and Figures 3 and 4 (section view). The IPIs monitor gross internal movements of Leroy Anderson Dam related to significant earthquake or rapid drawdown of the reservoir. We differentiate between the individual in-place inclinometer boring (IPI) and in-place inclinometer Little Dipper bi-axial sensors (IPIs).

Table 7
Locations of In-place Inclinometer Sensors (IPIs)
Leroy Anderson Dam

Crest Inclinometer IPI9-1* (boring 72-9-AS1)				
IPIs Designation	**X-axis & Y-axis**	Spacing between sensors (ft)	Sensor Depth (ft)	Sensor Elev. (ft)
IPIs 9-1	9-1X	36.5	36.5	610.5
	9-1Y	"	"	"
IPIs 9-2	9-2X	21.5	58	589.0
	9-2Y	"	"	"
IPIs 9-3	9-3X	21.5	79.5	567.5
	9-3Y	"	"	"
IPIs 9-4	9-4X	21.5	101	546.0
	9-4Y	"	"	"
IPIs 9-5	9-5X	21.5	122.5	524.5
	9-5Y	"	"	"
IPIs 9-6	9-6X	51.5	174	473.0
	9-6Y	"	"	"
Action Levels*		±0.05	±0.05	±0.05

notes:
1) * = formerly designated as IPI9-3
2) sensor spacing includes length of fiberglass connectorrod and length of se
3) +Yaxis is pointing upstream and +X axis is pointing to the left abutment
4) Boring surface elevation = 647 ft (at crest)
5) * yellow shade = Action Levels: see Nelson 2012
6) file: W:\Geology\Dams\Data\IPI\AndIPITabLocDSOD.xls

It is customary to assume that the bottoms of inclinometer borings are stable in order to calculate relative displacements upward along the entire length of the boring column. This is reasonable because the bottom of the inclinometer casing IPI9-1 is socketed into stable bedrock.

4.8.1 In-Place Inclinometer Sensor (IPIs) Data

Table 7 summarizes pertinent information on each IPIs including IPIs designation, drill hole designation, sensor depth, sensor elevation, and surface elevation at the top of the inclinometer boring.

Also shown on Table 7 are Action Levels (yellow shading) for each IPIs. Methods for determining Action Levels are summarized in Appendix A of the 2012 surveillance report (Nelson, 2012), which are based on specific reservoir levels for each inclinometer defined by historic data.

Figure 16 is a compilation of X-axis and Y-axis data plots for all IPIs, and shows inclinometer readings versus depth (i.e. elevation of sensor). Plots of incremental X-axis and cumulative X-axis data are shown in Figures 16a and 16b, respectively. Plots of incremental Y-axis and cumulative Y-axis data are shown in Figures 16c and 16d, respectively.

Due to the recent installation of a new sensor for IPIs9-6 and reinstallation of the remaining IPIs, the August 2012 installation date resulted in a reset of the data plots. It appears likely that after initial installation of the sensors there will be a period where minor adjustments of the IPI sensors will occur. To account for these adjustments we decided to define the initial reading as 11/13/12 as shown in Figure 16.

The in-place inclinometer surveys appear to be providing reliable and consistent data during the entire surveillance period. The in-place inclinometer data plots suggest relatively stable readings that indicate displacement of the embankment is not occurring. No significant gaps in the IPIs data are present during the current reporting period.

4.8.2 Outlier In-Place Inclinometer Data

Based on recent data, during 2013 in-place inclinometer movement values are well below the upper Action Levels. Due to the nature of displacement data, there are no lower Action Levels.

4.9 U.S.G.S. and District Strong Motion Accelerometers

4.9.1 U. S. Geological Survey Accelerometers

Seven Kinemetrics Model SMA-1 strong motion recorders (accelerometers) were installed in 1985 by the U.S. Geological Survey (U.S.G.S). Five accelerometers are installed on the downstream slope, one is situated about 150 feet south-southwest of the crest in the left abutment (see Figure 1), and one free field accelerometer is situated about 300 feet downstream of the toe of Anderson Dam. The accelerometers are operated and maintained by the U.S.G.S. District Dam Safety Program Unit personnel request seismic data from the U.S.G.S. if any of the seven instruments have recorded seismic accelerations after significant earthquakes occur in the vicinity of Anderson Dam.

During the current reporting period there are no accelerometer data to report.

4.9.2 District Accelerometer

An Altus Etna strong motion accelerometer manufactured by Kinemetrics is securely mounted on the floor of the blockhouse on the crest of the dam. The purpose of the accelerometer is to record accelerations in the vicinity of the dam in the event of an earthquake. The accelerometer continuously monitors ground acceleration and compares current acceleration levels to preset thresholds. When an excursion of the threshold acceleration value is detected, ADAS notifies the District with an alarm that the threshold condition (typically 0.03 g) was exceeded. No alarms were triggered during the period of this report.

ADAS is set up to query the accelerometer for possible data at a 10-minute frequency during every 24 hour period. In addition, ADAS routinely retrieves data from VWPs and IPIs every 10 minutes. These frequent-interval data are temporarily stored in flash cards in the ADAS instrumentation center located onsite in the block house on the crest of Anderson Dam. These data are only retrieved manually by District Dam Safety Program personnel after they have been alerted to an alarm condition of the accelerometer. Data flash cards are retrieved from the dam and taken back to the office, where all pertinent ADAS data recorded at 10-minute intervals are then compiled and analyzed.

During the current reporting period, there were no significant seismic events in the vicinity of Anderson Dam. Consequently, the strong motion accelerometer was not triggered and no acceleration data were collected.

5.0 VISUAL INSPECTIONS

The following significant inspections performed during the period of this report include:

5.1 DSOD Inspection

- April 22, 2013, performed annual DSOD inspection by DSOD engineers B. Vogler and T. Jimenez along with District personnel R. Jacobs, H. Desai, J. Nelson, B. Baker, S. Wu, M. Mooers, and J. Sparkman.

5.2 Other District Inspections

Several inspections, repairs, and maintenance related to work on the Automated Data Acquisition System (ADAS) at Anderson Dam were performed on the following dates by DSPU staff. Site visits on:

1. December 13, 2012, B. Baker and J. Nelson performed ADAS maintenance including battery replacement and functional test of the on-site accelerometer. Manual IPIs data was also collected.
2. February 14, 2013, J. Nelson and B. Baker observed drilling by the Anderson Dam Seismic Retrofit Project (ADSRP) planning/design team (AMEC and Pacific Geotechnical Engineering) to characterize site conditions and install piezometers at the downstream toe and right abutment area. District personnel also performed routine ADAS maintenance including battery replacement and manual IPIs data collection.
3. April 30, 2013, annual FERC inspection with District staff (H. Desai, R. Jacobs, M. Mooers, B. Baker, S. Wu, J. Nelson, and J. Sparkman), FERC Engineer E. Salire and G. Arya.
4. May 8, 2013, inspection to update the District's Post Earthquake Dam Assessment Program (PEDAP) and to orient potential PEDAP responders. District personnel included R. Jacobs, B. Baker, S. Wu, M. Mooers, H. Desai, N. Merrill, L. Fleming, K. Neuman, D. Honda, M. Jordan, K. Slama, and P. Thieman.
5. November 25, 2013, J. Nelson performed ADAS maintenance including troubleshooting non-functioning piezometers.

6.0 CONCLUSIONS and RECOMMENDATIONS

6.1 Conclusions

We have established new action levels and implemented new procedures for monthly evaluation of available monitoring data and outlier analysis, as described herein, including notifying DSOD of any apparent significant deviations from normal behavior.

Overall, for the period of December 2012 through December 2013, there were no significant modifications of Anderson Dam or appurtenant structures, and no significant operational changes or events that would impact the surveillance data or its interpretation.

Except for the minor anomalous data from vibrating wire piezometer VWP-31, our review of the monitoring data presented herein does not indicate any significant outlier data, or any unusual or abnormal changes in the monitoring data during the subject reporting period.

Minor problems with surveillance sensors include outlier data from VWP-31 located in left abutment bedrock, which has been providing erratic data since September 2013. The erratic values from VWP-31 range from viable readings to elevation values ~200 to 400 feet above normal, which indicates possible hardware/electronic problems with the sensor. We do not believe the erratic behavior of VWP-31 is related to adverse embankment/foundations conditions. The District will perform field testing of the electronic equipment associated with VWP-31 to attempt to determine the reasons for the erratic behavior. The District will continue to monitor the behavior of VWP-31 and will keep DSOD apprised.

Our review of the surveillance data, and our periodic safety inspections, indicate that Anderson Dam and it's appurtenant structures appears to show normal responses to the surrounding environment, aging process, and external events.

6.2 Recommendations for Next Surveillance Period

As discussed below, the following changes are expected in the next reporting period:

6.2.1 No Longer Provide Plots of In-Place Inclinometer Data

Based on a July 11, 2013 telecom with DSOD, the District and DSOD agreed that the only changes in monitoring that applied to District dams, including Anderson Dam had to do with in-place inclinometers. DSOD indicated that no reporting requirement was needed for in-place inclinometer sensors (IPIs) unless the District notices adverse trends in the data or other concerns with the IPIs.

6.2.2 Other Surveillance Items

1. We will continue monitoring all existing and new instrumentation as described in this report

2. Regular District site inspections and annual DSOD inspections will continue, as well as well as inspections that may be triggered by instrument outlier data.

3. Additional site inspections and monument surveys will be conducted after significant earthquakes or other potentially disruptive activity.

4. We do not anticipate replacement or repair work of any instruments to be required in the next annual reporting period.

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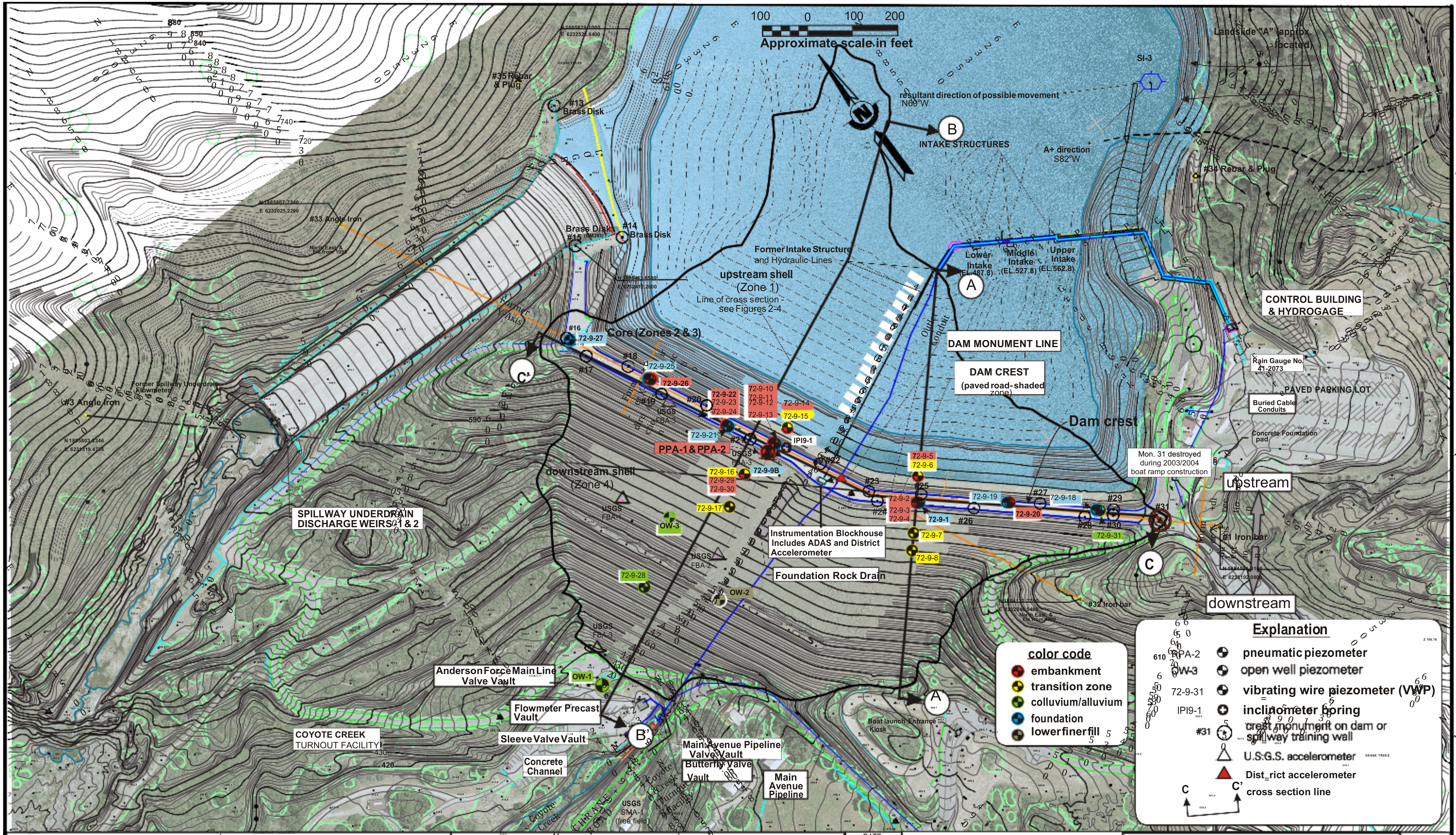


Reference information and notes:

1) This map is a compilation of aerial mapping, survey field data, and digitized construction maps. Maximum error could be **± one foot vertical and horizontal; error greater for upstream topographic lines (see note 7)**

2) Grid is based on California Coordinate System, Zone III, NAD 83.

3) Elevations based on N.G.S. Vertical datum, NAVD 88. The DE between NGVD 29 and NAVD 88 is 2.80'

4) Photogrammetric mapping: Transvision, Photo date 12/11/97; color photo date 2006

5) file W:\geology\DAMS\Historic Dam Geology\anderson\ANDHistgeo.cdr

6) selected 1987-88 dam raise values in feet shown in red

7) upstream dam topography (dashed lines) from as-built 1988 "Leroy Anderson Dam Intake Structure Modification, Sheet 2, scale 1"=100', dated 1-8-88, from 10-7-87 aerial photography, modified to NGVD 88

DATE
12/08/11
DESIGN
JLN
DRAWN
JLN
CHECKED
SW

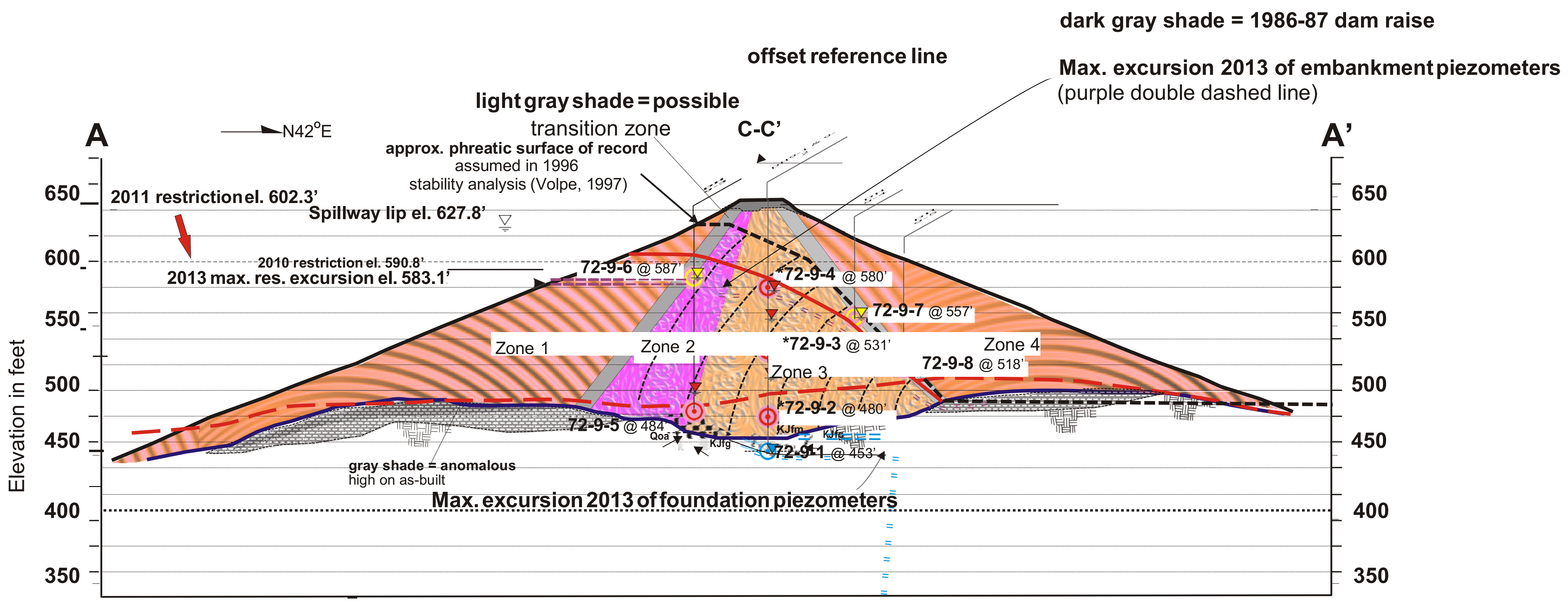
Santa Clara Valley Water District

Topographic Map
Surveillance Instrumentation
Leroy Anderson Dam

SCALE
1" = 200'

FIGURE
1

Section A-A' (sta. 6+00)


dark gray shade = 1986-87 dam raise
offset reference line
Max. excursion 2013 of embankment piezometers
(purple double dashed line)
light gray shade = possible
transition zone
C-C'
approx. phreatic surface of record
assumed in 1996
stability analysis (Volpe, 1997)
A
N42°E
A'
650
600
550
500
450
400
350
Elevation in feet
2011 restriction el. 602.3'
Spillway lip el. 627.8'
2010 restriction el. 590.8'
2013 max. res. excursion el. 583.1'
72-9-6 @ 587'
*72-9-4 @ 580'
72-9-7 @ 557'
Zone 1
Zone 2
*72-9-3 @ 531'
Zone 4
Zone 3
72-9-8 @ 518'
72-9-5 @ 484
*72-9-2 @ 480'
Qoa
KJfg
KJfm
KJfg
72-9-1 @ 453'
gray shade = anomalous
high on as-built
Max. excursion 2013 of foundation piezometers

Explanation

boring number

72-9-8 vibrating wire piezometer

excavated topography (as-built) adjusted to DIP drill hole logs

excavated topography (as-built) corrected 2.8' for new datum

original topography corrected 2.8' for new datum

* = installed using grout-in methods (see Nelson, 2009b)

all other piezometers installed using sand-pack methods

Embankment/Fill Units from DIP/SSE1A

Zones 1 (downstream) and 4 (upstream): rockfill

Transition Zones, downstream and upstream

Zone 2 upstream core

Zone 3 downstream core

Bedrock & Soil Foundation Units from DIP/SSE1B

Qoa/Qc = Quaternary older alluvium and/or colluvium

QTsc = Plio-Pleistocene Santa Clara Fm

KJfm = Franciscan Complex melange

KJfg = Franciscan Complex greenstone

◎ red = embankment

◎ yellow = transition zone

◎ green = colluvium/alluvium

◎ blue = foundation

2013 max excursion

▼ embankment

▼ transition zone

▼ colluvium/alluvium

▼ foundation bedrock

Phreatic Surfaces & Equipotential Lines

Phreatic surface of record Volpe, 1997

Phreatic surface Action Level - tied to 2011 res. restriction

2013 maximum excursion embankment piezometers

2013 maximum excursion foundation piezometers

approx. equipotential lines (GEI, 2009)

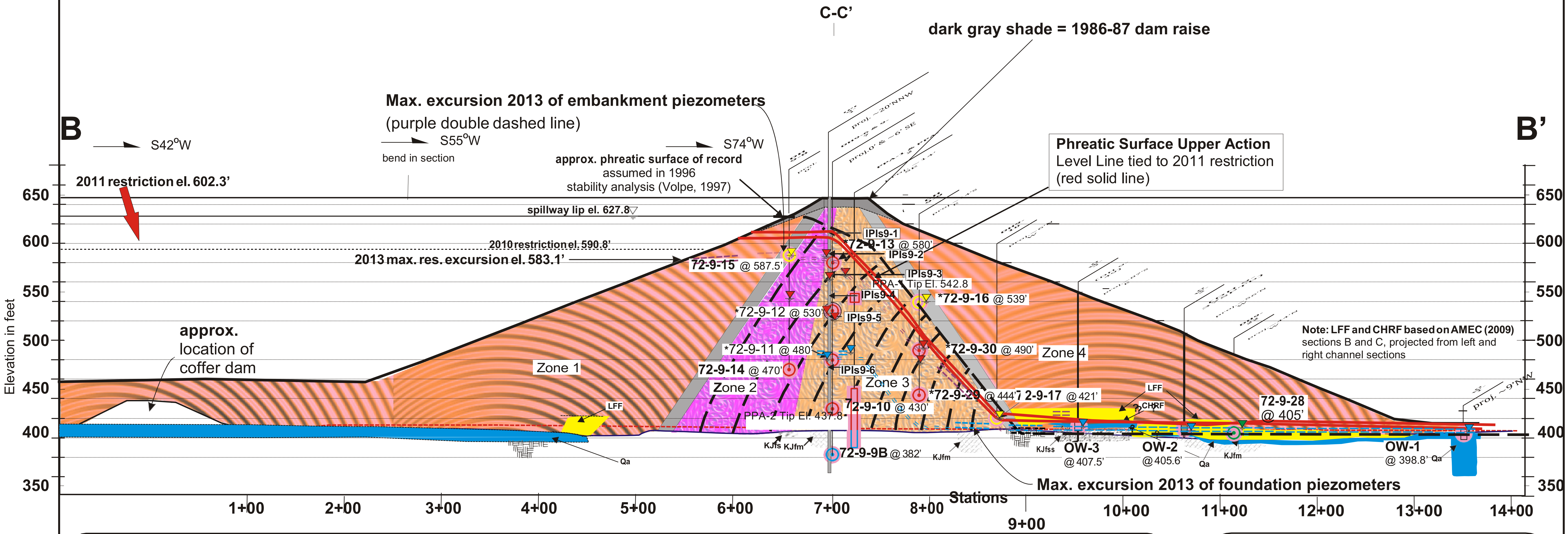
Notes:

1) File: W:\geology\dams\Historic_Dam_Geology\Anderson\andxsecA-A'rev.cdr

2) basis of elevations is NAVD 1988-elevations are 2.80' higher than NGVD 1929

DATE 12/09/13	Santa Clara Valley Water District	**Cross Section A-A'** Leroy Anderson Dam	SCALE 1"=100'
DESIGN JLN			FIGURE 2
DRAWN JLN			
CHECKED MRM			

Section B-B' (transverse max section along thalweg)



Explanation

boring number

72-9-28 ⊙ vibrating wire piezometer

▯ open well & pneumatic piezometers

IPI9-1 automated slope indicator

DH9-20 geophysical

DH9-20 lithologic logging

excavated topography (as-built) corrected 2.8' for new datum

excavated topography (as-built) adjusted to DIP drill hole logs

original topography corrected 2.8' for new datum

*=installed using grout-in methods (see Nelson, 2009b)
all other piezometers installed using sand-pack methods

Embankment/Fill Units from DIP/SSE1A

☐	Zones 1 (downstream) and 4 (upstream): rockfill
▨	Transition Zones, downstream and upstream
▨	Zone 2 upstream core
☐	Zone 3 downstream core
■	Construction haul road fill (CHRF)
▨	Lower Finer Fill (LLF), downstream and upstream

Bedrock and Foundation Soil Units from DIP/SSE1A

■	Qa/Qc = Quaternary alluvium and/or colluvium
▨	KJfm = Franciscan Complex melange
▨	KJfss = Franciscan Complex graywacke sandstone

⊙ red = embankment
⊙ yellow = transition zone
⊙ green = colluvium/alluvium
⊙ blue = foundation

▣ lower finer fill (LFF)

= PPA-2 is composite piezo in emb. & foundation

2013 max excursion

▼ embankment
▼ transition zone
▼ colluvium/alluvium/LFF
▼ foundation bedrock

Phreatic Surfaces & Equipotential Lines

Phreatic surface of record Volpe, 1997

Phreatic surface Upper Action Level - tied to 2011 res. restriction

2013 maximum excursion embankment piezometers

2013 maximum excursion foundation piezometers

approx. equipotential lines (GEI, 2009)

Notes:
1) File: W:\geology\dams\historic dam geology\anderson\andxsecB-B'rev.cdr
2) basis of elevations is NAVD 1988-elevations are 2.80' higher than NGVD 1929
3) Downstream and upstream foundation materials taken from AMEC (2010 draft)

DATE	12/09/13
DESIGN	JLN
DRAWN	JLN
CHECKED	MRM

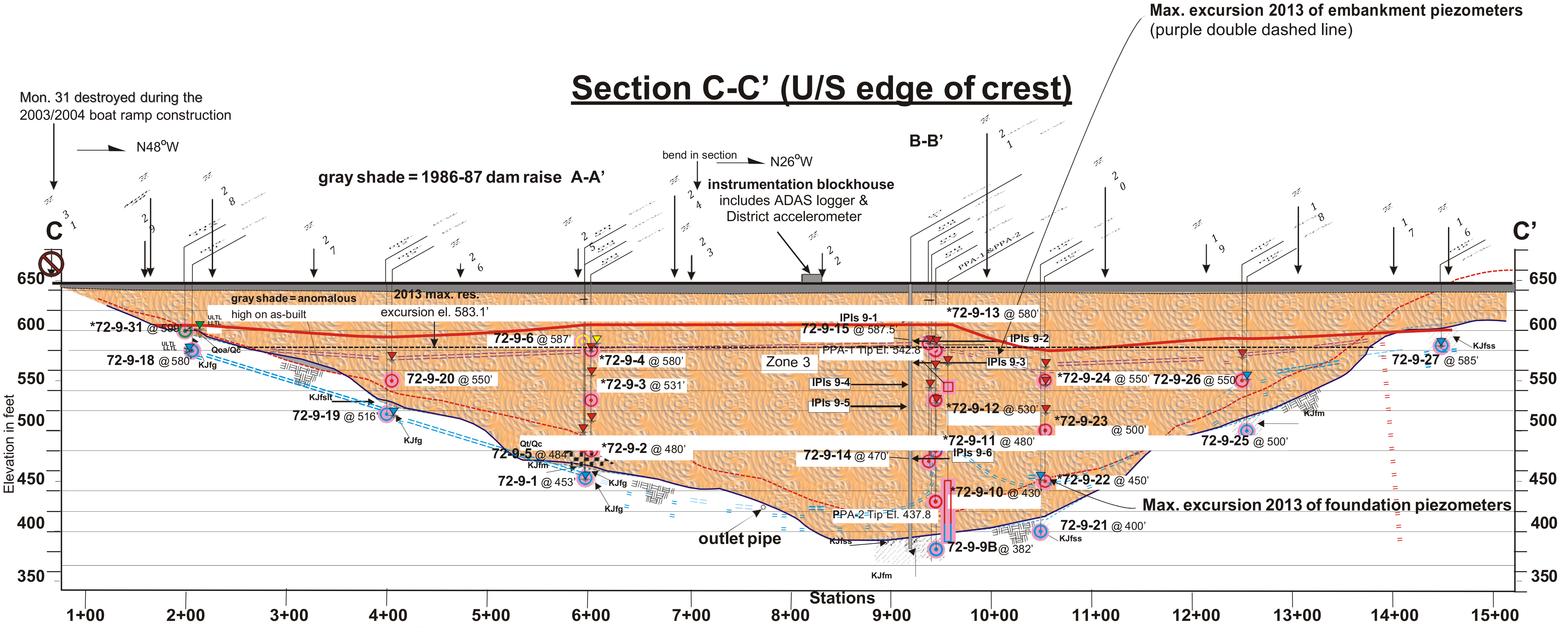
Santa Clara Valley Water District

Cross Section B-B'

Leroy Anderson Dam

SCALE	1"=100'
FIGURE	3

Section C-C' (U/S edge of crest)



Explanation

boring number

72-9-27 vibrating wire piezometer

IPI9-1 automated slope indicator

geophysical/ lithologic logging

open well & pneumatic piezometers

excavated topography (as-built) corrected 2.8' for new datum

excavated topography (as-built) adjusted to DIP drill hole logs

original topography corrected 2.8' for new datum

* = installed using grout-in methods (see Nelson, 2009b)

all other piezometers installed using sand-pack methods

Embankment/Fill Units

▨ Zone 3 downstream core

Bedrock and Foundation Soil Units from DIP

▨ Qoa/Qc = Quaternary older alluvium and/or colluvium

▨ KJfm = Franciscan Complex melange

▨ KJfg = Franciscan Complex greenstone

▨ KJfss = Franciscan Complex sandstone

◎ red = embankment

◎ yellow = transition zone

◎ green = colluvium/alluvium

◎ blue = foundation

= PPA-2 is composite piezo in emb. & foundation

2013 max excursion

▼ embankment

▼ transition zone

▼ colluvium/alluvium

▼ foundation bedrock

Phreatic Surfaces

Phreatic surface Action Level
- tied to 2011 res. restriction

2013 maximum excursion embankment piezometers

2013 maximum excursion foundation piezometers

Notes:

1) File: W:\Geology\DAMS\Historic_Dam_Geology\Anderson\andxsecC-CDIP.cdr

2) basis of elevations is NAVD 1988-elevations are 2.80' higher than NGVD 1929

DATE
12/09/13
DESIGN
JLN
DRAWN
JLN
CHECKED
MRM

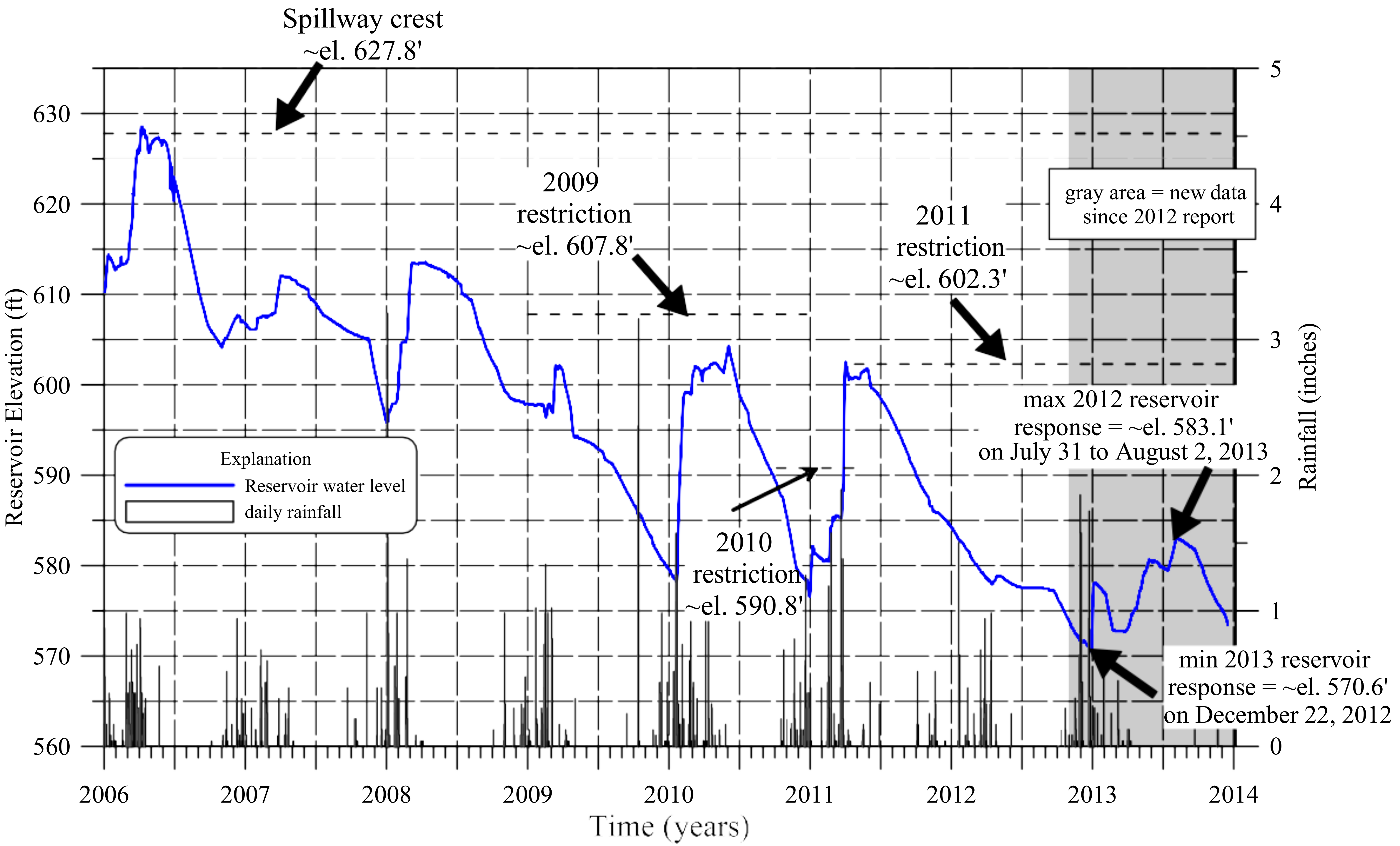
Santa Clara Valley Water District

Longitudinal Cross Section C-C'

Leroy Anderson Dam

SCALE
1"=100'

FIGURE
4



Spillway crest
~el. 627.8'

2009
restriction
~el. 607.8'

2011
restriction
~el. 602.3'

gray area = new data
since 2012 report

max 2012 reservoir
response = ~el. 583.1'
on July 31 to August 2, 2013

2010
restriction
~el. 590.8'

min 2013 reservoir
response = ~el. 570.6'
on December 22, 2012

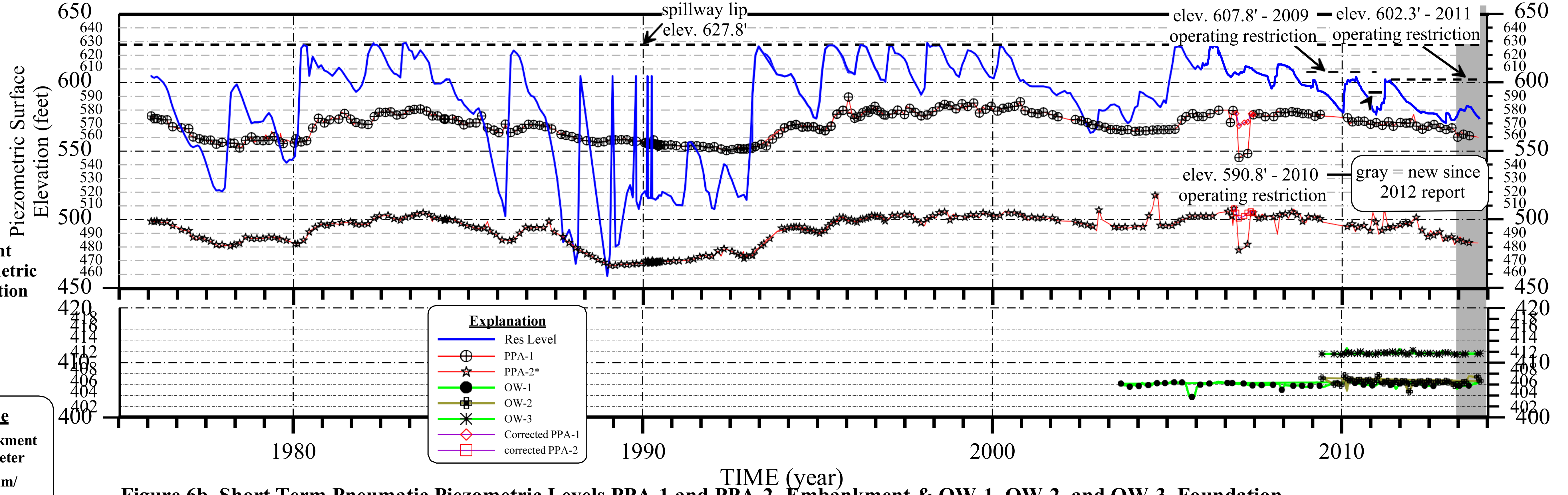
Notes: 1) basis of elevations is NAVD 1988 - values are 2.8 feet higher than NGVD 1929
2) file W:\geology\dams\annual dam safety reports\DSOD\Anderson\2013\piez\Andresplot-13

Santa Clara Valley Water District

Daily Reservoir Elevation and Rainfall 2006-2013
Leroy Anderson Dam

FIGURE
5

Figure 6a. Long Term Pneumatic Piezometric Levels PPA-1 and PPA-2- Embankment & OW-1, OW-2, and OW-3, Foundation

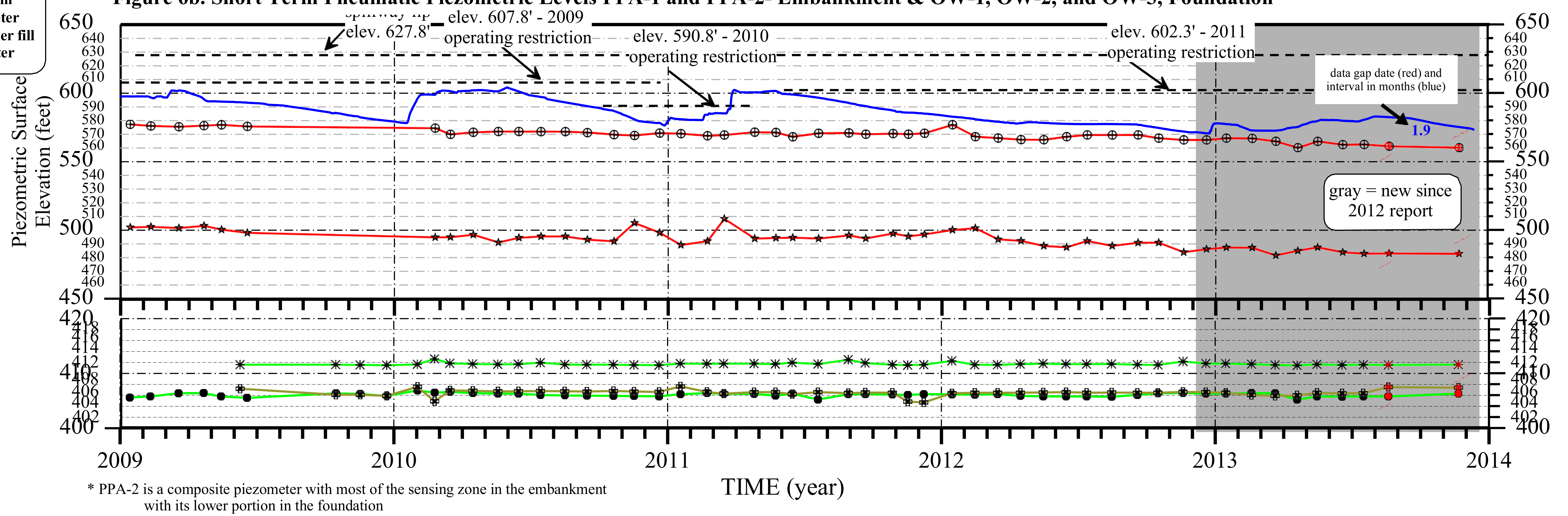


note different vertical Piezometric Surface Elevation scales

line code

🟥	**embankment piezometer**
🟩	**alluvium/ colluvium piezometer**
▬	**lower finer fill piezometer**

Figure 6b. Short Term Pneumatic Piezometric Levels PPA-1 and PPA-2- Embankment & OW-1, OW-2, and OW-3, Foundation



* PPA-2 is a composite piezometer with most of the sensing zone in the embankment with its lower portion in the foundation

Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than NGVD 1928
2) File W:\Geology\DAMS\Annual Dam Safety Reports\DSOD\Anderson\2012\Piez\AndDSODpneu&ows-13.grf

Santa Clara Valley Water District

Long and Short Term Piezometric Data - Pneumatic and Open Wells, Embankment & Downstream Foundation
Leroy Anderson Dam

FIGURE
6

Figure 7a. Long Term Piezometric Levels Section A-A' Embankment

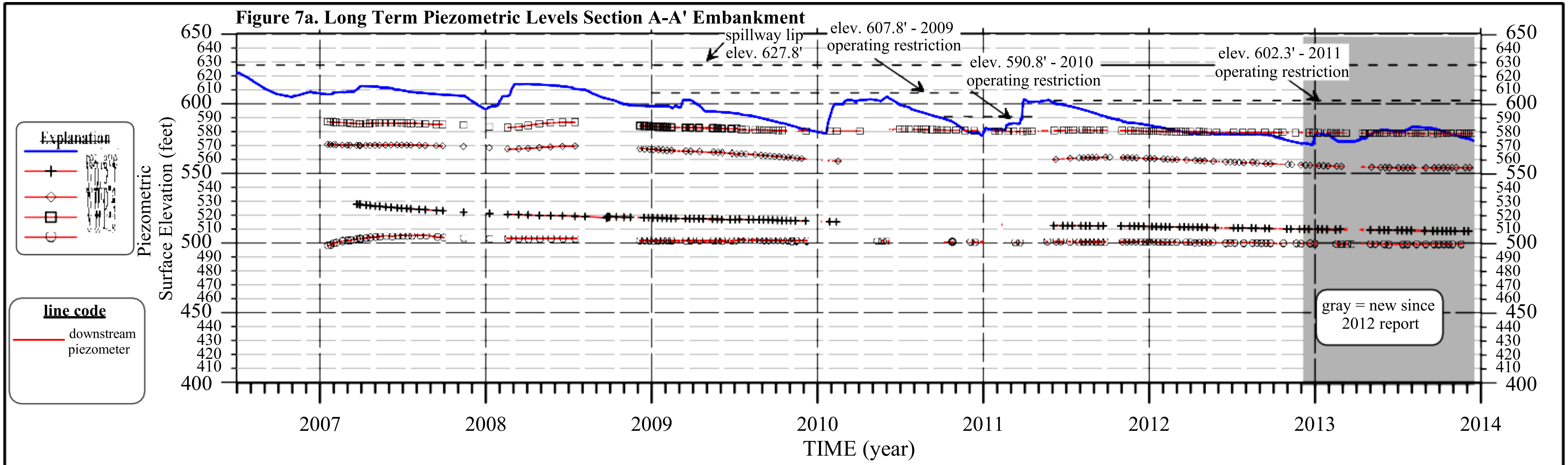
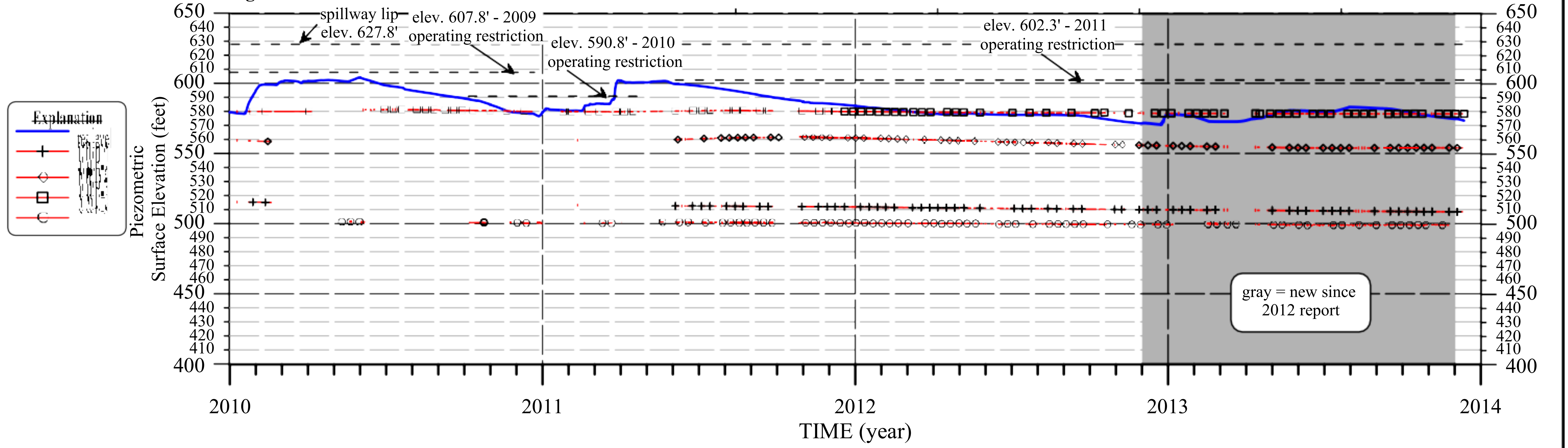


Figure 7b. Short Term Piezometric Levels Section A-A' Embankment



Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than NGVD 1928
2) File W:\Geology\DAMS\Annual Dam SafetyReports\DSOd\Anderson\2013\Piez\AndDSODSectionA-12.grf

Santa Clara Valley Water District

Long Term and Short Term VW Piezometric Data
Section A-A' - Embankment
Leroy Anderson Dam

FIGURE 7

Figure 8. Long Term Piezometric Levels Section B-B' Embankment

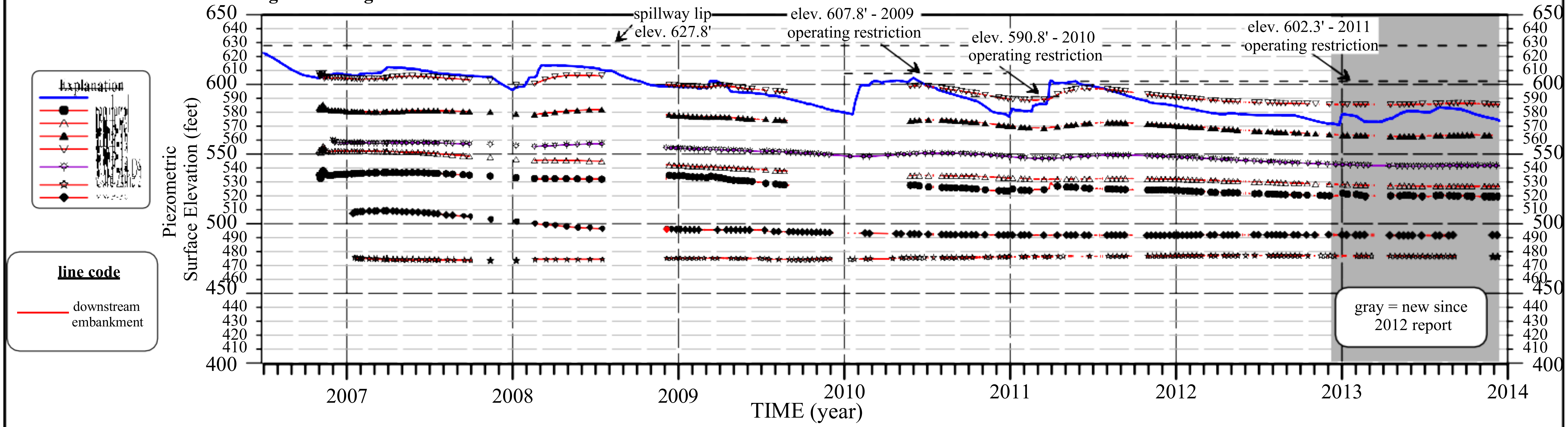
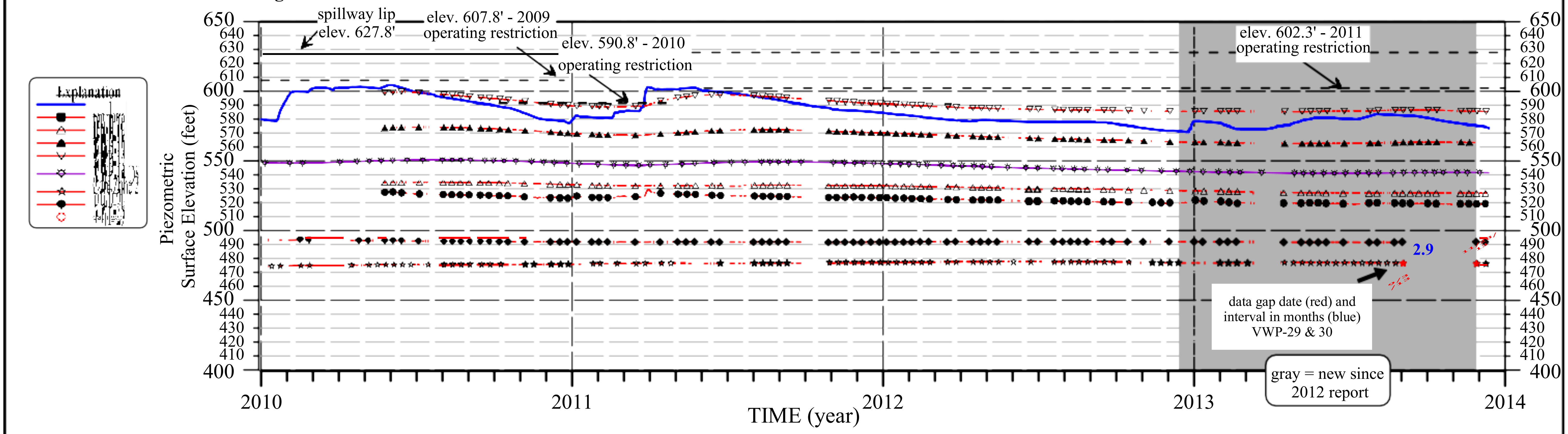


Figure 8. Short Term Piezometric Levels Section B-B' Embankment



Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than NGVD 1928
2) File W:\Geology\DAMS\Annual Dam Safety Reports\DSOD\Anderson\2013\Piez\AndDSODSectionB-13.grf

Santa Clara Valley Water District

Long Term and Short Term VW Piezometric Data
Section B-B' - Embankment
Leroy Anderson Dam

FIGURE
8

Figure 9a. Long Term Piezometric Levels - Section C-C' Embankment

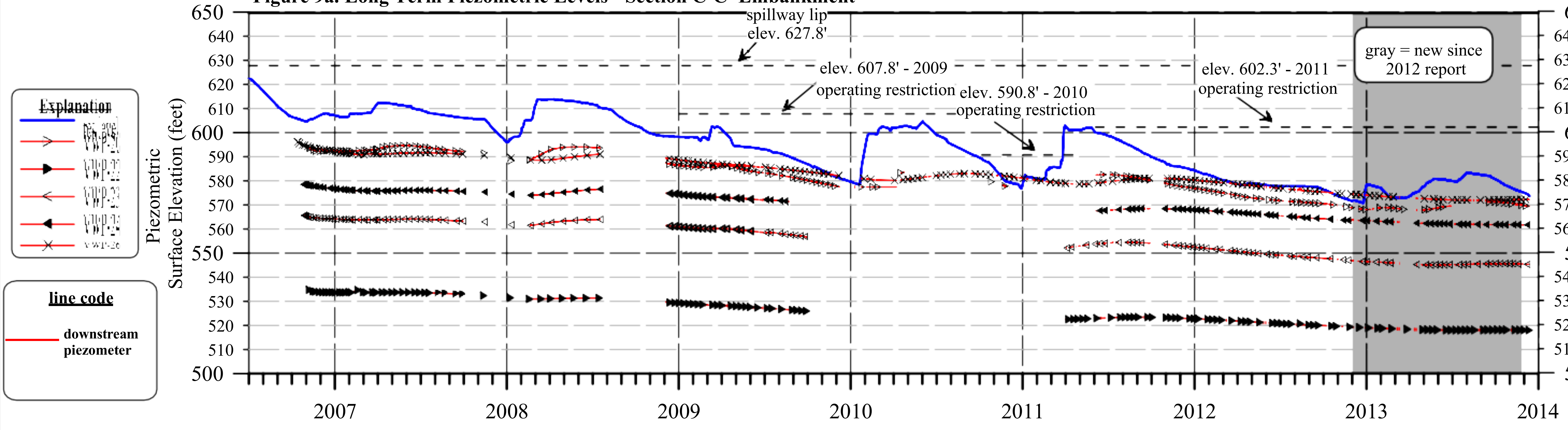
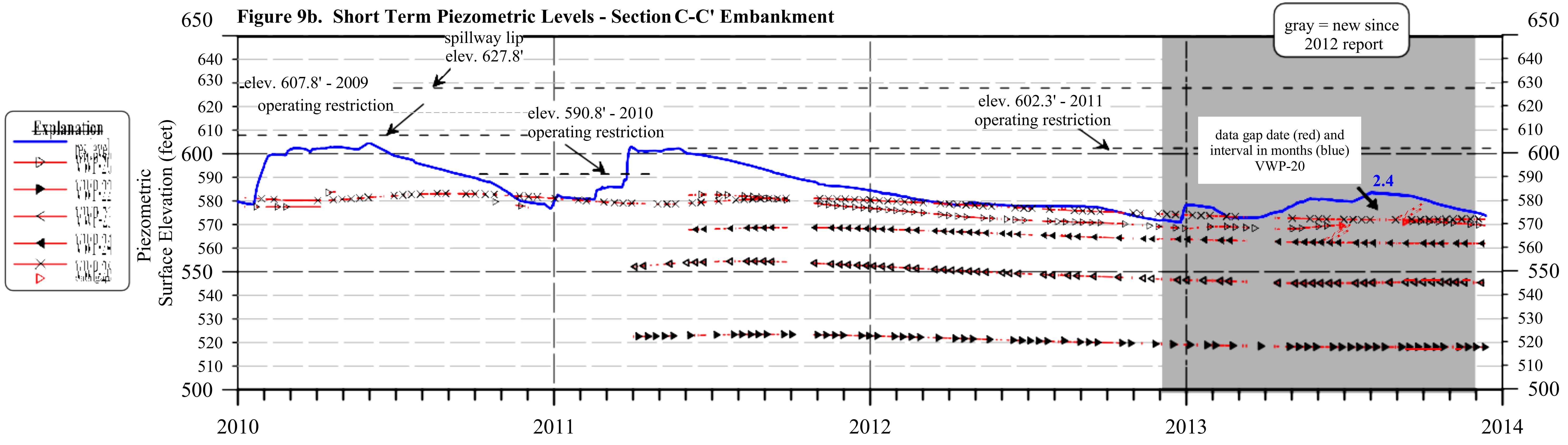


Figure 9b. Short Term Piezometric Levels - Section C-C' Embankment



Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than NGVD1928
2) File W:\Geology\DAMS\Annual Dam Safety Reports\FERC\AnnualReports\2013\Piez\AndDSODSectionC-13.grf

Santa Clara Valley Water District

Long Term and Short Term VW Piezometric Data
Section C-C' - Embankment
Leroy Anderson Dam

FIGURE
9

Figure 10a. Long Term Piezometric Levels Foundation Bedrock and Alluvium

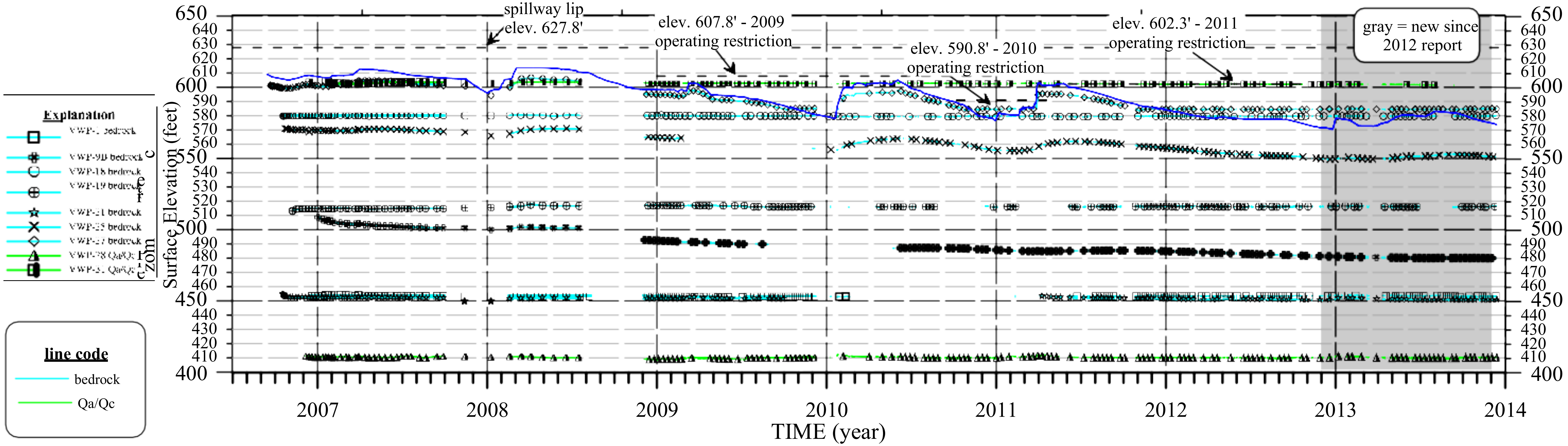
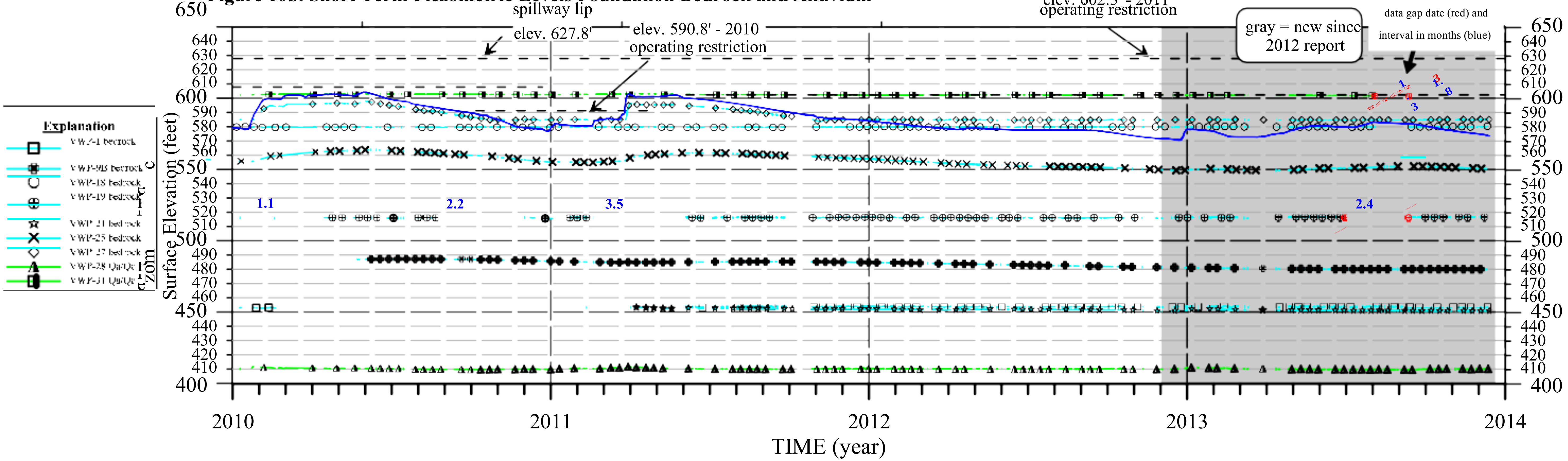


Figure 10b. Short Term Piezometric Levels Foundation Bedrock and Alluvium



Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than NGVD 1928
2) File W:\Geology\DAMS\Annual DamSafety Reports\DSOD\Annual Reports\Anderson\2013\Piez\AndDSODFound-13.grf

Santa Clara Valley Water District

Long and Short Term VW Piezometric Data - Foundation

Leroy Anderson Dam

FIGURE
10

Figure 11a. Long Term Piezometric Levels Transition Zones

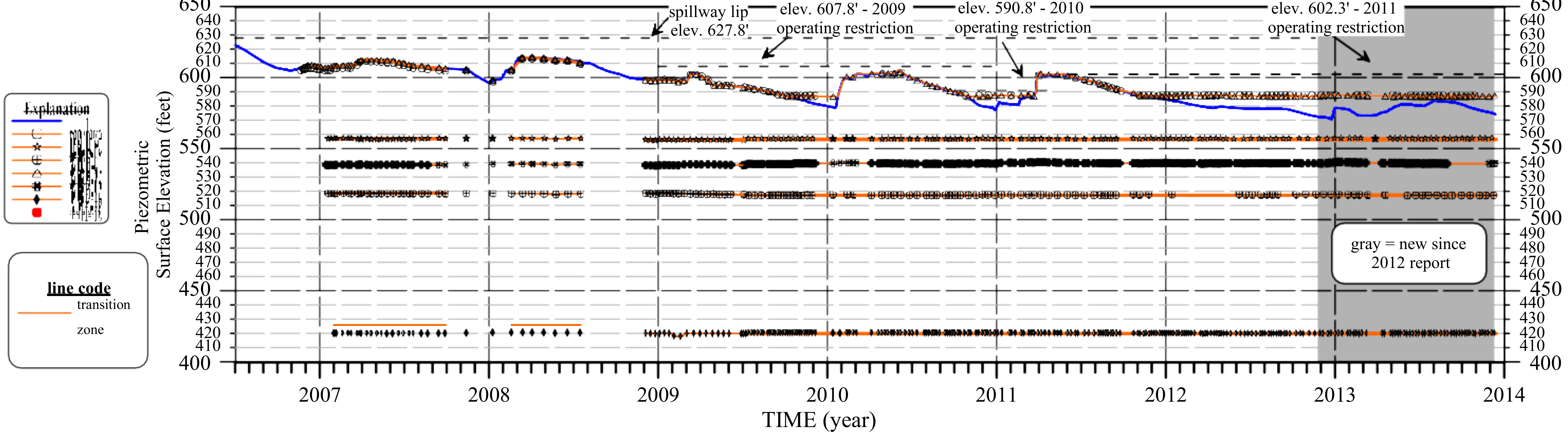
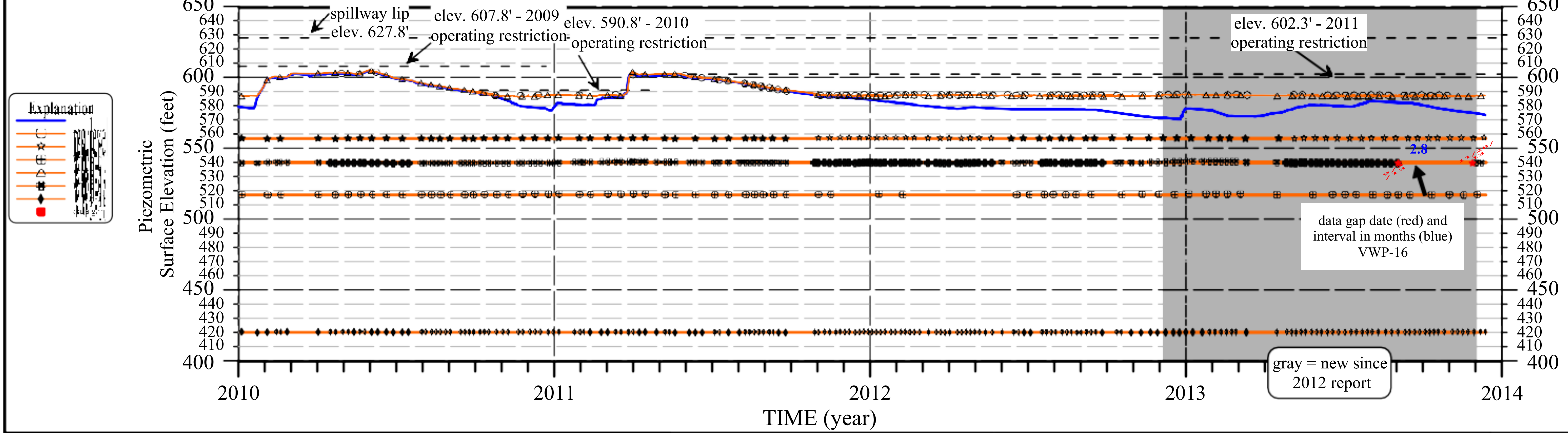


Figure 11b. Short Term Piezometric Levels Transition Zones



Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than NGVD 1928
2) File W:\Geology\DAMS\Annual Dam Safety Reports\DSOD\Anderson\2013\Piez\AndDSODTZ-13.grf

Santa Clara Valley Water District

Long Term and Short Term VW Piezometric Data - Transition Zones
Leroy Anderson Dam

FIGURE
11

Figure 12a. Long Term Weir Discharge - Spillway Underdrains

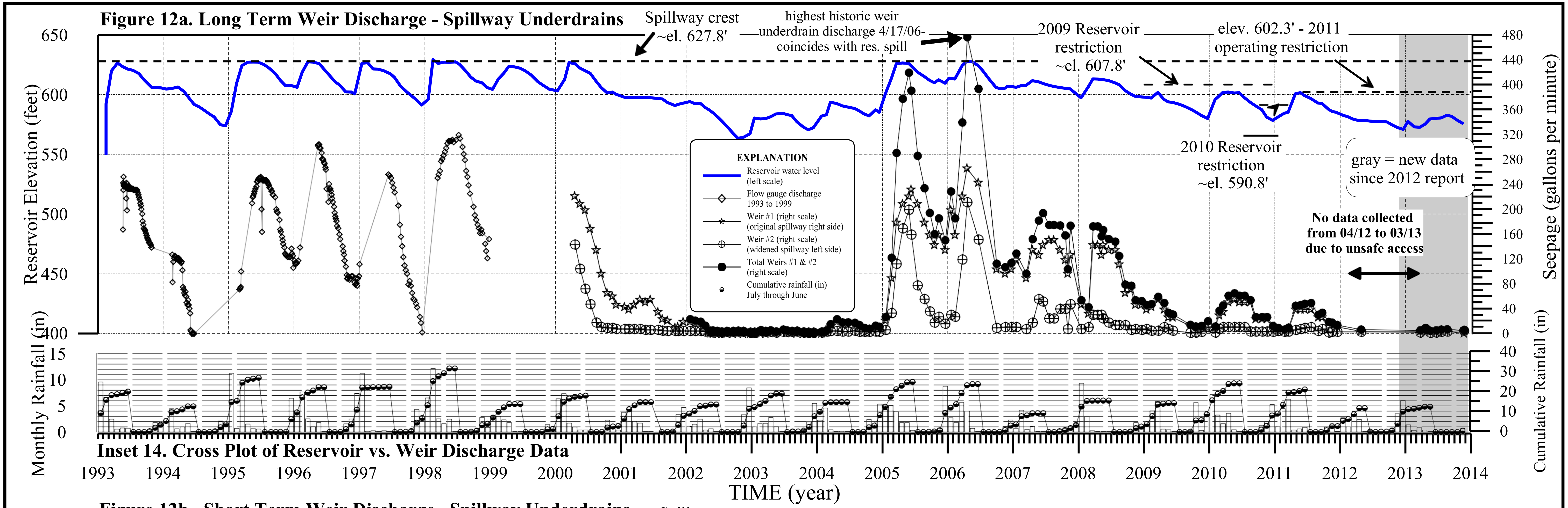
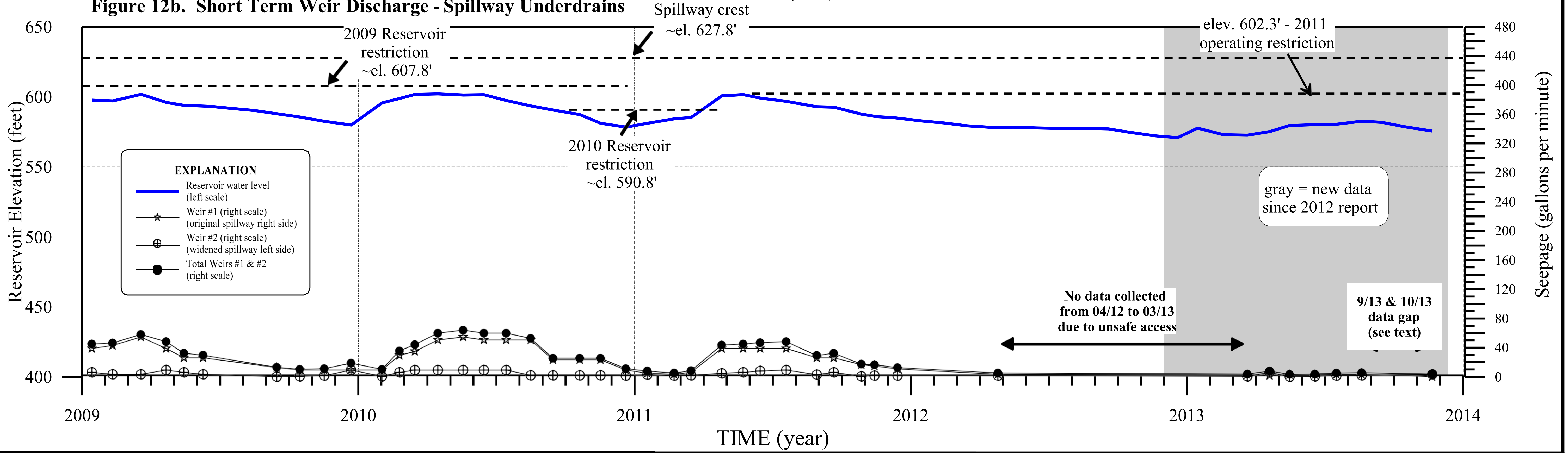


Figure 12b. Short Term Weir Discharge - Spillway Underdrains



Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than NGVD 1928
2) File W:\Geology\DAMS\Annual Dam Safety Reports\DSOD\Anderson\2013\weir\AndweirDSOD-13.grf

Santa Clara Valley Water District

Long and Short Term Weir Discharge Data
Spillway Underdrains
Leroy Anderson Dam

FIGURE
12

Figure 13a. Long and Short Term Local Vertical Displacements - Downstream Monuments

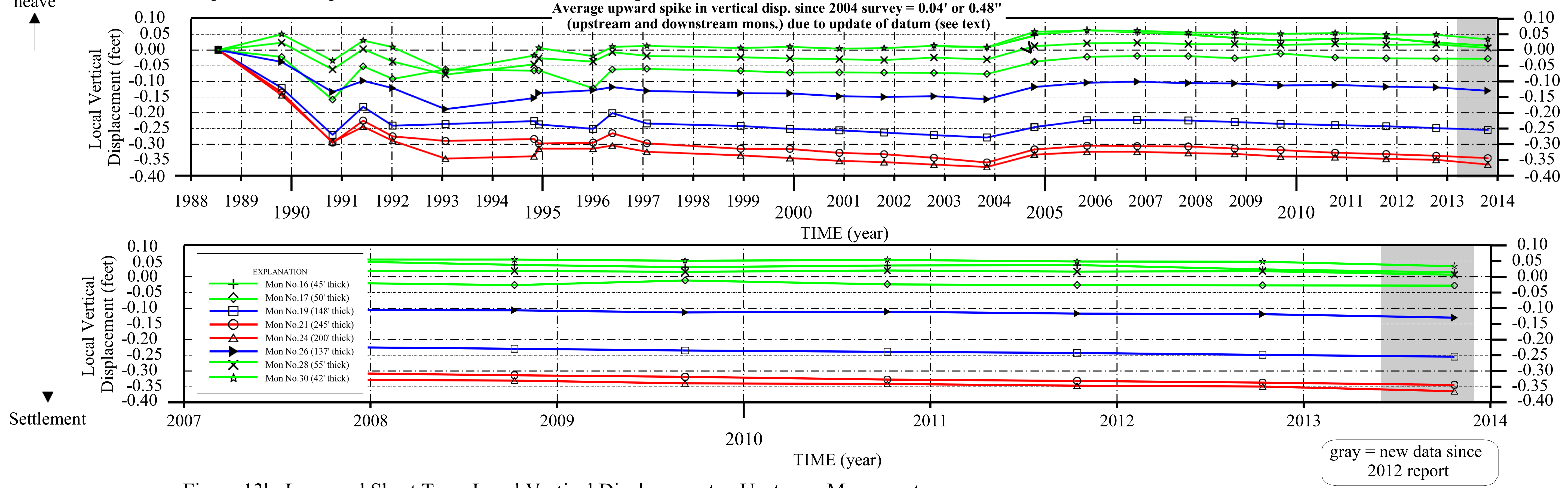
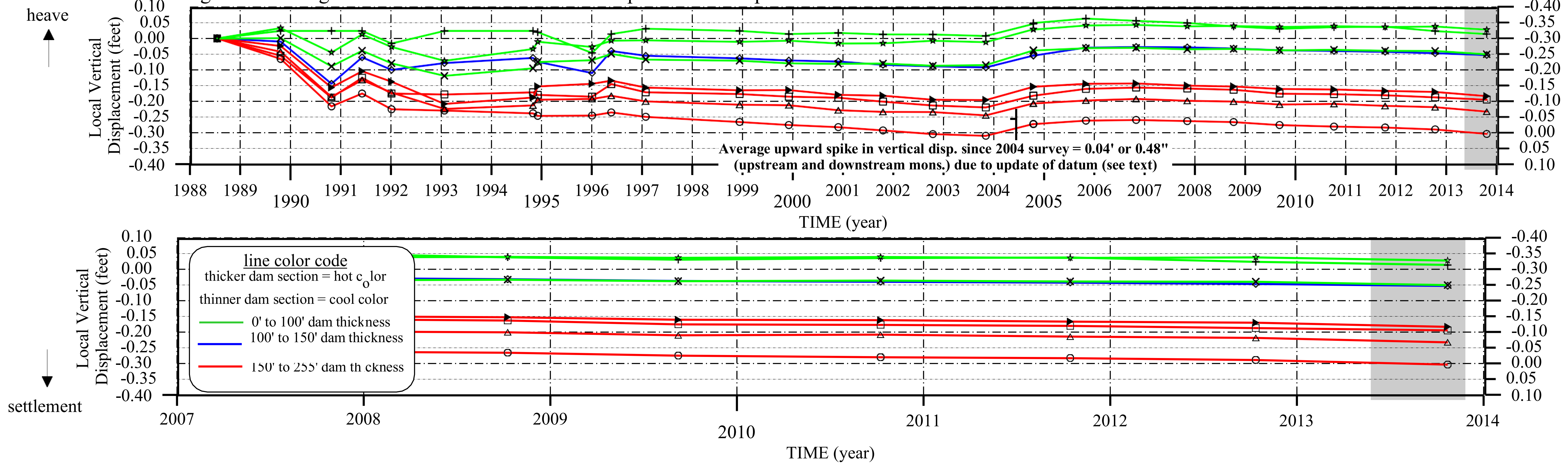


Figure 13b. Long and Short Term Local Vertical Displacements - Upstream Monuments



Notes:
1) File W:\Geology\DAMS\Annual Dam Safety Reports\FERC\AnnualReport\2013\survey\AndDSODDS&USvertPlots-13.grf
2) Since the 2004 survey the District no longer shows changes in datums

Santa Clara Valley Water District

Long and Short Term Local Vertical Displacement
- Downstream and Upstream Crest Monuments
Leroy Anderson Dam

FIGURE
13

Figure 14a. Long and Short Term Local Transverse Displacements - Downstream Monuments

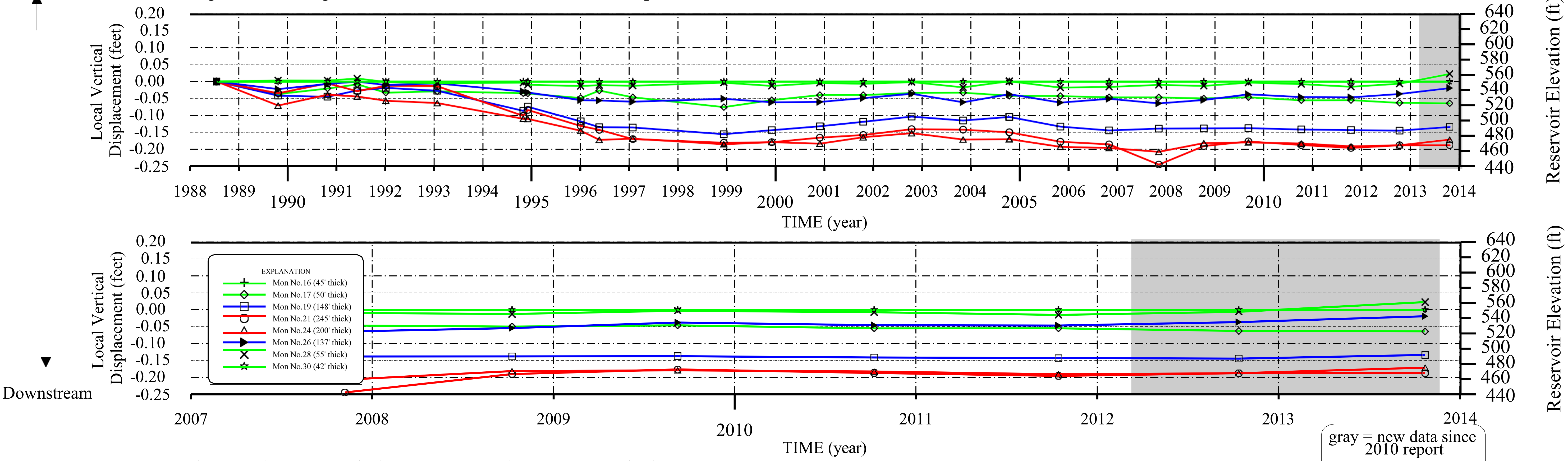
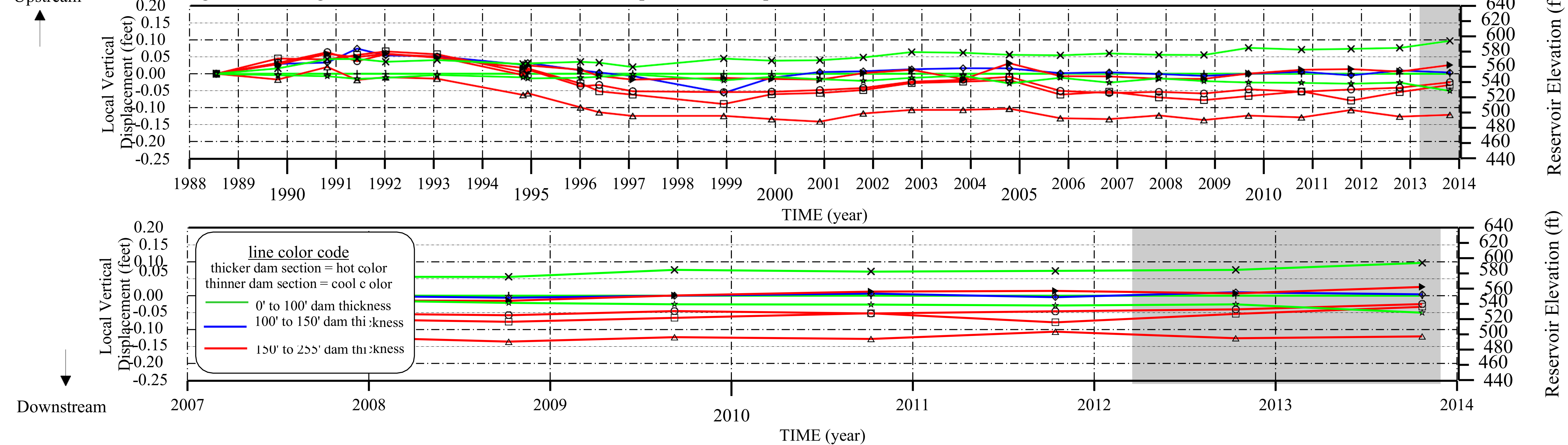


Figure 14b. Long and Short Term Local Transverse Displacements - Upstream Monuments



Notes:
1) File W:\Geology\DAMS\Annual Dam Safety Reports\FERC\Annual Reports\2012\survey\AndDS&UTransPlots-12.grf
2) Since the 2004 survey the District no longer shows changes in datums

Santa Clara Valley Water District

Long and Short Term Local Transverse Displacement
- Downstream and Upstream Crest Monuments
Leroy Anderson Dam

FIGURE
14

Figure 15a. Long Term Local Vertical Displacements - Training Wall Monuments

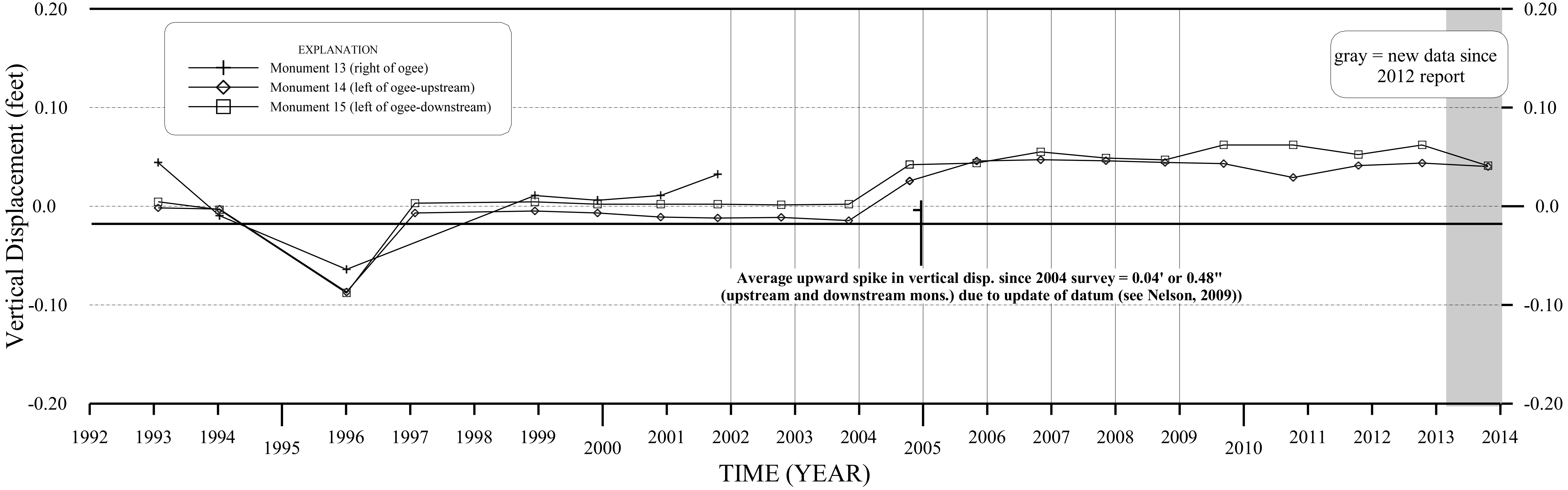
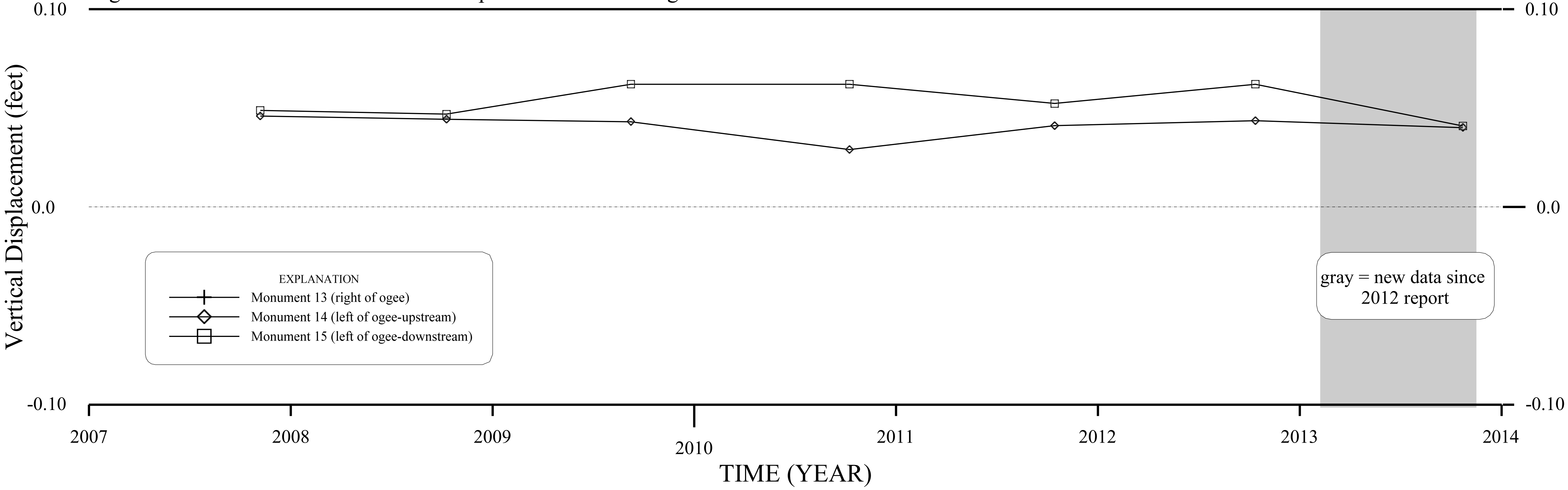


Figure 15b. Short Term Local Vertical Displacements - Training Wall Monuments



Notes:
1) Mon. 13 not surveyed since October 2001
2) File W:\geology\annual dam safety reports\DSOD\Anderson\annual reports\2013\survey\AndDSODtrainWVert-13.grf
3) Since the 2004 survey the District no longer shows changes in datums

Santa Clara Valley Water District

Long and Short Term Vertical
Displacements - Spillway Training Walls
Leroy Anderson Dam

FIGURE
15

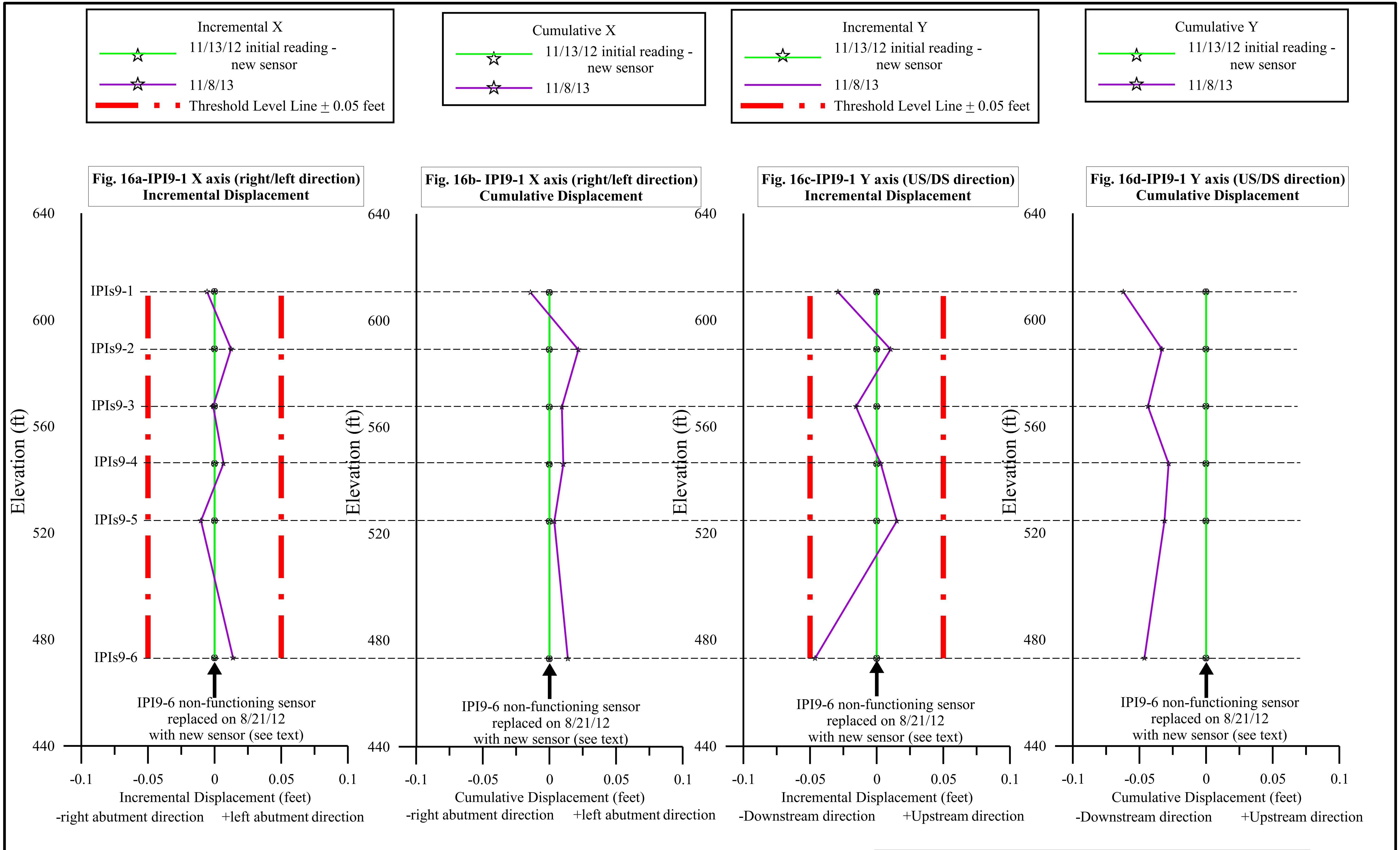


Fig. 16a-IPI9-1 X axis (right/left direction) Incremental Displacement

Fig. 16b- IPI9-1 X axis (right/left direction) Cumulative Displacement

Fig. 16c-IPI9-1 Y axis (US/DS direction) Incremental Displacement

Fig. 16d-IPI9-1 Y axis (US/DS direction) Cumulative Displacement

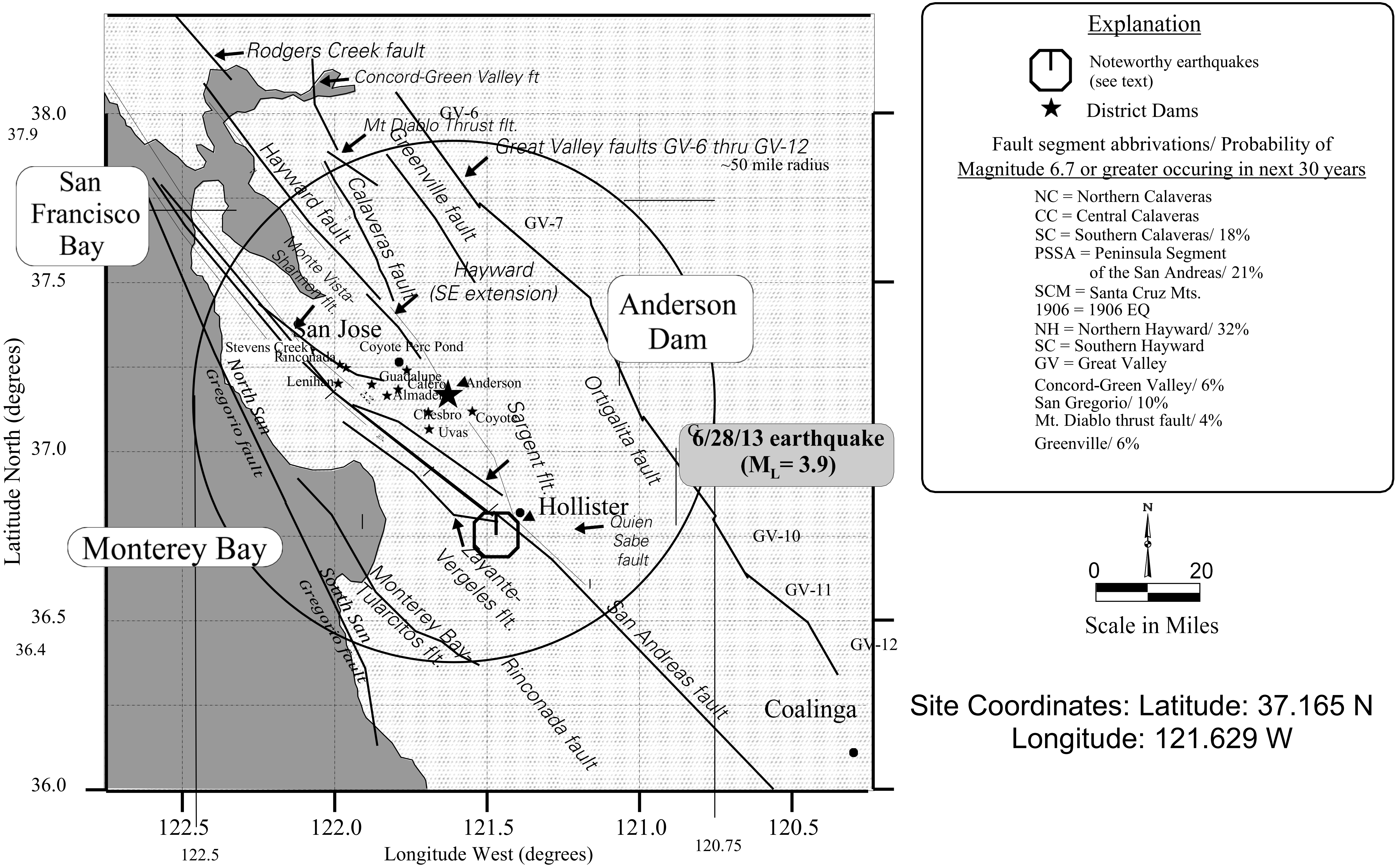
Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.89 feet higher than NGVD 1928
2) File W:\Geology\DAMS\Annual Dam Safety Reports\DSOD\Annual Reports\2013\IPIs\AndIPIsX&Y-13a.grf

Santa Clara Valley Water District

Recent In-Place Crest Inclinometer Sensor Data

Leroy Anderson Dam

FIGURE
16



Explanation

Noteworthy earthquakes (see text)

★ District Dams

Fault segment abbrivations/ Probability of Magnitude 6.7 or greater occuring in next 30 years

NC = Northern Calaveras
CC = Central Calaveras
SC = Southern Calaveras/ 18%
PSSA = Peninsula Segment of the San Andreas/ 21%
SCM = Santa Cruz Mts.
1906 = 1906 EQ
NH = Northern Hayward/ 32%
SC = Southern Hayward
GV = Great Valley
Concord-Green Valley/ 6%
San Gregorio/ 10%
Mt. Diablo thrust fault/ 4%
Greenville/ 6%

Site Coordinates: Latitude: 37.165 N
Longitude: 121.629 W

Notes: 1) File W:\geology\dams\annual dam safety reports\DSOD\Anderson\2013\seis\Andseis-13.grf

DATE 11/21/11
DESIGN JLN
DRAWN JLN
CHECKED DEH

Santa Clara Valley Water District

Regional Fault Map Showing Noteworthy Earthquakes

Leroy Anderson Dam

SCALE 1"=20'

FIGURE 17